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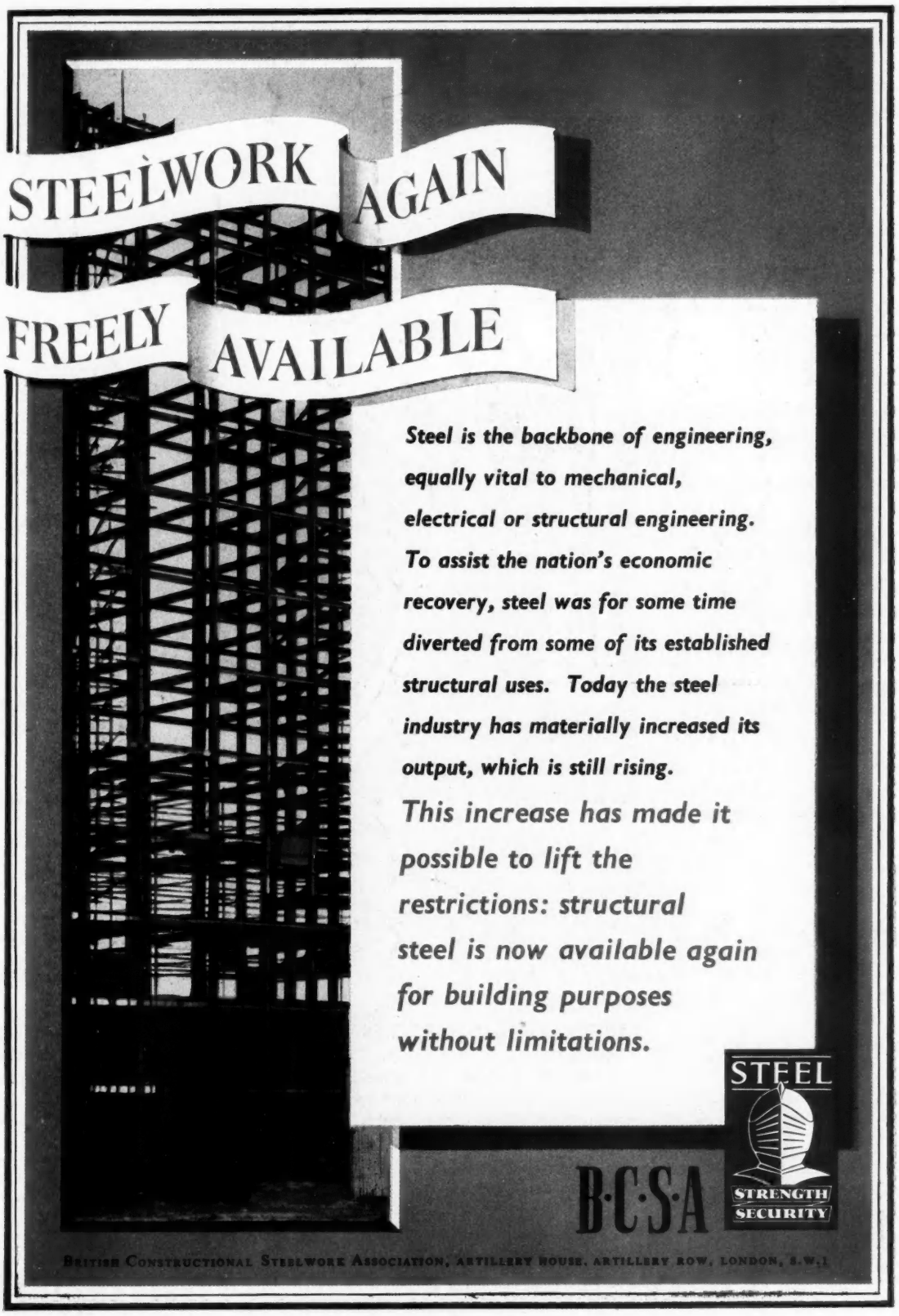
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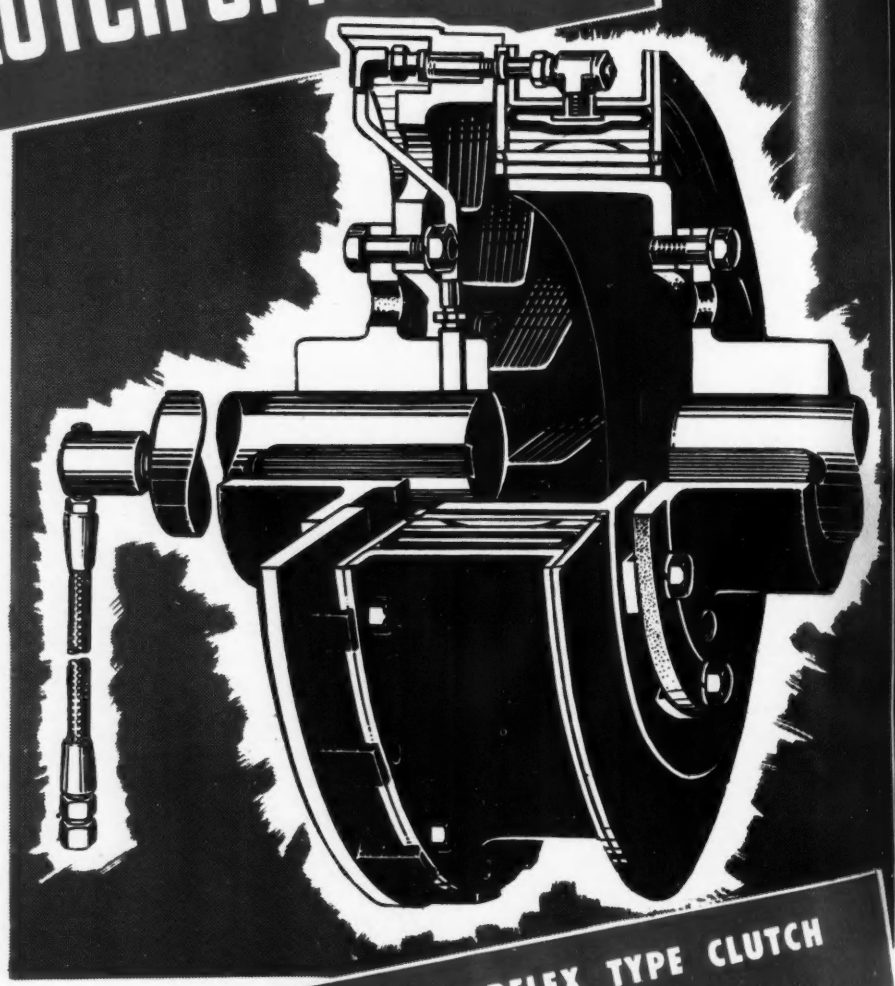

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THE ENGINEER

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

NEW SOUTH WALES UNIVERSITY OF TECHNOLOGY

SYDNEY, AUSTRALIA

Applications are invited for appointment to the following CHAIRS. Salary £2112 (Australian) per annum :—

FOUNDATION CHAIR of CIVIL ENGINEERING.—The successful applicant will be required to take charge of the existing School of Civil Engineering and, in addition to his teaching duties, to direct research in collaboration with other Schools of the University and with industry.

FOUNDATION CHAIR of MECHANICAL ENGINEER.—The successful applicant will be required to take charge of the existing School of Mechanical Engineering and, in addition to his teaching duties, to direct research in collaboration with the Nuffield Research Professor of Mechanical Engineering, other Schools of the University and with industry.

CHAIR of ELECTRICAL ENGINEERING. The successful applicant will be required to take charge of the existing School of Electrical Engineering and, in addition to his teaching duties, to direct research in collaboration with other Schools of the University and with industry.

Applicants should give full details of academic, professional or industrial experience.—Six copies of applications (together with six copies of testimonials and other supporting documents) should reach the Agent-General for New South Wales, 56/57, Strand, London, W.C.2, by 1st July, 1953. Appointees will be eligible, subject to medical examination, to contribute to the New South Wales Superannuation Fund, which will provide an annual pension of up to £1014 (Australian). Their first-class shipping fares to Sydney will be allowed.—Further particulars may be obtained from the Agent-General for New South Wales at the above address. E8739

THE UNIVERSITY OF LIVERPOOL

DEPARTMENT OF MECHANICAL ENGINEERING

ASSISTANT LECTURER OR LECTURER

Applications are invited for the post of ASSISTANT LECTURER or LECTURER in the Department of Mechanical Engineering. The initial salary for an Assistant Lecturer will be £450 per annum, with allowance for age, experience and qualifications ; the initial salary for a Lecturer will be within the range £550–£800 per annum, according to qualifications and experience.

Applications, stating age, academic qualifications and experience, together with the names of three referees, should be received not later than 6th June, 1953, by the undersigned, from whom further particulars of the conditions of appointment may be obtained.

STANLEY DUMBELL,
Registrar.

May, 1953. E8663

ROYAL NAVAL COLLEGE

GREENWICH, LONDON, S.E.10

LECTURERS

(a) LECTURER in Department of Applied Mechanics, (b) LECTURER in Department of Mathematics. Applications are invited for appointment to these posts in September, 1953, or as soon after as possible. Candidates must be British subjects. Those for (a) should possess a First or Second-Class Honours Degree in Mechanical Engineering, and preference will be given to candidates with a knowledge of one or more of the following subjects : (i) materials and structures, (ii) fluid mechanics, including supersonics, (iii) ballistics, (iv) servo-mechanisms. Candidates for (b) should possess a First or Second-Class Honours Degree in Mathematics.

Appointment will be as Junior Lecturer (salary £400–£650) or Senior Lecturer (£750–£950), according to age, qualifications and experience. A pay addition (approximately 10 per cent of the first £500 of salary and 5 per cent of the balance) will also be allowable. In certain circumstances a starting salary above the minimum may be authorised. Advancement to higher posts is possible. Consideration would be given to the secondment for an agreed period of serving members of the Scientific Civil Service.—Letters of application, accompanied by names of three referees and a statement of previous experience, to be sent as soon as possible to the Director of Studies, R.N. College, Greenwich, S.E.10, from whom further particulars may be obtained. The closing date for applications is 15th June, 1953. E8730

NORWICH EDUCATION COMMITTEE

THE NORWICH CITY COLLEGE AND ART SCHOOL
IPSWICH ROAD, NORWICH

Principal : FRANK BRIERS, B.Sc., D.Phil. (Oxon)

TEACHER OF MECHANICAL ENGINEERING

Wanted for 1st September, 1953, TEACHER of MECHANICAL ENGINEERING subjects to Ordinary National Certificate standard and for City and Guilds Craft courses. Candidates should hold as a minimum qualification a Higher National Certificate in Mechanical or Production Engineering and should preferably be Associate Members or Graduates of the Institution of Mechanical Engineers or the Institution of Production Engineers.

Salary in accordance with the Burnham Scale for Teachers in Establishments of Further Education, Grade A (£415–£18–£670 per annum, with appropriate allowances).

Application forms, which may be obtained from the Director of Education, City Hall, Norwich, on receipt of a stamped, addressed envelope, should be returned to the Principal as soon as possible. E8778

PUBLIC APPOINTMENTS

GLAMORGAN EDUCATION COMMITTEE

GLAMORGAN TECHNICAL COLLEGE, TREFOREST

ASSISTANTS, GRADES A AND B

Required for September, 1953, at the Glamorgan Technical College, Treforest :—

SIX ASSISTANTS (Grade B) for :—

1. Mechanical engineering, to work up to Higher National Certificate standard. Preference will be given to candidates able to offer, in addition, electrical engineering subjects to Ordinary National Certificate standard. Candidates should possess a Degree in Engineering or equivalent professional qualification with suitable industrial experience.

2. Automobile engineering practice. Candidates will be required to assist with general workshop courses and must possess either a full Technological Certificate in Automobile Engineering Practice of the City and Guilds of London Institute or a Higher National Certificate in Mechanical Engineering, together with experience in the motor vehicle servicing industry. Experience of electrical arc and/or acetylene welding an advantage.

3. Mining engineering. Candidates should possess a Colliery Manager's Certificate and/or a Degree in Mining.

4. Mine surveying. Candidates should possess a Degree in Mining. Preference will be given to a person holding the Mine Surveyor's Certificate.

5. Electronics, to teach the subject to tele-communications, radio engineering and degree students. Applicants should possess a Degree or equivalent qualification in Science or Electrical Engineering. Preference will be given to candidates with industrial or academic experience in applied electronics.

6. Chemistry and chemical engineering or fuel technology, to assist in teaching the subjects to degree and diploma standards. Candidates should possess either a Degree or equivalent qualification in Chemical Engineering or a Degree or equivalent qualification in Chemistry, together with additional qualifications in chemical engineering and/or fuel technology.

ONE ASSISTANT (Grade A) for :—

Commercial subjects, including economics and accountancy. The successful candidate will be expected to assist in the teaching of management subjects.

Salaries in accordance with the Burnham Technical Scales.—Application forms, obtainable from the undersigned on receipt of a stamped, addressed foolscap envelope, must be returned by 1st June, 1953. Canvassing will disqualify.

EMLYN STEPHENS,
Director of Education.

County Hall, Cardiff. E8736

THE ROYAL TECHNICAL COLLEGE, GLASGOW
(IN AFFILIATION WITH THE UNIVERSITY OF GLASGOW)

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

LECTURESHIPS AND ASSISTANT LECTURESHIPS

Applications are invited for LECTURESHIPS and ASSISTANT LECTURESHIPS in (a) Applied Mechanics, in (b) Heat Engines, and in (c) Engineering Drawing. Candidates should have a good Honours Degree and industrial experience ; teaching experience an advantage.

The Engineering Courses are conducted on a sandwich system which leaves the summer term free for research, opportunities for which are exceptionally good.

Salary on scale : Lecturer, £600 × £50–£1150 ; Assistant Lecturer, £500 × £25–£600.

Forms of application can be had from the Secretary of the College. E8596

SURREY EDUCATION COMMITTEE

RICHMOND TECHNICAL INSTITUTE, KEW ROAD, RICHMOND

FULL-TIME APPOINTMENTS

Required for September, 1953. Applications are invited from suitably qualified men with industrial and teaching experience for two FULL-TIME APPOINTMENTS, to teach in preliminary technical, City and Guilds and S.I. National Certificate courses in engineering for day release students. Good workshop experience will be expected, and one of the applicants must be capable of preparing coach-building classes for the City and Guilds Examinations. Some evening work may be involved. Burnham Scale for Grade A Assistants : men, £415 by £18 to £670 p.a., plus London allowance.

Application forms obtainable from the Principal on receipt of stamped (2½d.), addressed envelope from the Principal, to be returned within a fortnight of the appearance of this advertisement. E8772

ROYAL AIRCRAFT ESTABLISHMENT TECHNICAL COLLEGE

FARNBOROUGH, HANTS

VICE-PRINCIPAL

Farnborough, Hants, Royal Aircraft Establishment Technical College, requires full-time VICE-PRINCIPAL. Duties include responsibility for day and evening classes and some lecturing up to Final B.Sc. (Eng) standard. Qualifications : Honours Degree in Mechanical or Aeronautical Engineering, with considerable teaching and industrial (or research) experience. Salary, £1000 by £25 to £1150, subject to usual superannuation deductions. Additionally, £150 p.a. will be paid for duties as Vice-Principal, together with special addition to salary of £40 p.a.—Details and forms from Principal, to whom completed forms must be returned within fourteen days of this notice. E8733

PUBLIC APPOINTMENTS

UNION OF SOUTH AFRICA

PROVINCE OF NATAL

ENGINEER, GRADE IV

Applications are invited from suitably qualified persons for appointment on contract to posts of ENGINEER, Grade IV, in the Roads Department of the Natal Provincial Administration. The salary scale applicable is £400 by £50 to £900 per annum. Appropriate experience may be recognised in determining the commencing salary on the basis of one notch on the scale for each complete year gained after complying with the minimum professional requirements for appointment up to a maximum o five years.

A temporary cost-of-living allowance is at present payable at prescribed public service rates, the present rates being :—Married men, £320 per annum ; single men, £100 per annum.

Vacation leave accumulates and may be granted at the rate of 38 days per annum, and sick leave at the rate of 120 days on full pay and 120 days on half pay in each cycle of three years.

Applicants must be medically fit and possess a Civil Engineering Degree of an approved university or an equivalent qualification. A knowledge of English and/or Afrikaans is necessary.

The following contracts will be available for completion by candidates :—

1. Citizens of a Commonwealth country or of the Republic of Ireland :

(a) Three-year contract which provides for free passages and rail fares for the successful applicants to Natal, half basic salary will be paid during voyage, extension of the contract by mutual consent and free return passages, &c., on completion of the contract.

(b) Five-year contract, which, in addition to the provisions mentioned under (a), provides for free passages and rail fares for the successful applicants' families.

2. Citizens of a European country other than the United Kingdom or the Republic of Ireland :

(a) Four-year contract on same conditions as quoted for (a) above.

(b) Six-year contract on same conditions as provided in (b) above.

Selected candidates will be interviewed by the Chief Engineer, Roads Department, during the period May to October, 1953, at various university centres.

Applications, indicating age, qualifications, marital status, experience, &c., should be addressed to the Staff Clerk, Room 102, South Africa House, Trafalgar Square, London, W.C.2, to reach him not later than the 30th May, 1953.

The Roads Department has its own Maintenance, Construction and Planning Divisions, the latter having its own Highway Planning, Materials and Bridge Design Sections and spends some 3½ million pounds sterling annually. E8729

LEICESTER No. 3 HOSPITAL MANAGEMENT COMMITTEE

HOSPITALS ENGINEER

Applications are invited for the post of HOSPITALS ENGINEER for the group of Hospitals controlled by the Management Committee. Applicants should have hospital experience, be capable draughtsmen, and hold a recognised engineering qualification. They must have a sound knowledge of the efficient operation and maintenance of steam boiler plant, electrical generation and distribution and of engineering services generally as applied to a large hospital. Salary will be in accordance with the Ministry of Health Scale, viz. : £750–£855 per annum. The post is superannuable and a house is available upon a service tenancy. Forms of application can be obtained from the undersigned on the receipt of a stamped, addressed envelope.

H. PAGE,
Secretary.

The Towers Hospital,
Humberstone,
Leicester,
May 15th, 1953 E8749

CROWN AGENTS FOR THE COLONIES

DEVELOPMENT OFFICER (LAND PLANNING)

DEVELOPMENT OFFICER (Land Planning) required for the Gold Coast Local Civil Service, Agricultural Department, for one tour of 18/24 months. Salary £940 by £40 to £1180 a year. Outfit allowance £60. Gratuity £100 a year. Free passages. Liberal leave on full salary. Candidates should have practical experience of mechanised farming, farm management and maintenance of tractors and agricultural machinery, also in construction and maintenance of farm buildings, roads and drainage systems. Ability to handle labour and train junior staff is required.

Apply in writing to the Crown Agents, 4, Millbank, London, S.W.1, stating age, name in block letters, full qualifications and experience, and quoting M3A/33728/EH. E8718

MINISTRY OF SUPPLY

AERONAUTICAL AND MECHANICAL ENGINEERS

AERONAUTICAL and MECHANICAL ENGINEERS required by Ministry of Supply at R.A.E., Farnborough, Hants, for experimental and theoretical work on the strength of airframe structures and other light engineering structures. Qualifications : Higher School Cert. (Science) or equivalent, but Degree or H.N.C. in Mech. or Aero. Engineering may be an advantage. Experience of structural design, including strength calculations and strength tests, required ; experience on airframe structures desirable. Salary within range, Experimental Officer (min. age 26), £597–£754 ; women somewhat less. Posts unestablished.—Application forms to M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting Ref. No. C.256/53A. E8734

PUBLIC APPOINTMENTS

BOROUGH OF HENDON

BOROUGH ENGINEER AND SURVEYOR'S DEPARTMENT

TRANSPORT & ELECTRICAL SECTION

Applications are invited for the following posts in the Transport and Electrical Section of the Department :—

(1) ASSISTANT SUPERINTENDENT.
(2) FOREMAN-IN-CHARGE of FITTERS' WORKSHOPS.
(3) FOREMAN-IN-CHARGE of ELECTRICIANS.
(4) MOTOR FITTER.
(5) FITTER/WELDER.

The conditions appertaining to each appointment are as follows :—

(1) ASSISTANT SUPERINTENDENT. The salary will be in accordance with Grades [illegible] laneous V/VI of the National Scales (£480, rising by annual increments of £15 to a maximum of £[illegible] annum). London weighting at the current rate of present £30 per annum at age 26 or over) will be payable in addition to the above salary. The commencing salary will be determined by the experience and qualifications of the successful applicant.

The appointment will be terminable by one month's notice on either side and will be subject to the National Scheme of Conditions of Service for Local Government Superannuation Act of 1937, and to the passing of a medical examination.

Applicants must have a wide practical experience in mechanical and electrical engineering as applied to installations and maintenance of plant and machinery, together with a knowledge of road transport maintenance and repairs, contractors' plant, steam and water services, and electrical installations for both light and power.

Application forms can be obtained from the Borough Engineer and Surveyor at the Town Hall, Hendon, N.W.4, and must be returned to the Borough Engineer not later than 10th June, 1953.

(2) Foreman-in-Charge of Fitters and Workshops. The rate of pay will be 4s. 6d. per hour.

Applicants must have served a recognised apprenticeship to automobile engineering and be experienced in all branches of vehicle repair, preventive maintenance, including bodywork and painting.

(3) Foreman-in-Charge of Electricians. The rate of pay will be 4s. 6d. per hour.

Applicants must have served a recognised electrical apprenticeship and be fully experienced in all branches of electrical installation work for both light and power. A knowledge of domestic refrigeration would be an advantage.

(4) Motor Fitter. The rates of pay will be in accordance with those laid down by the Joint Negotiating Committee of the Local Authorities Services (Engineering Craftsmen), at present 3s. 11d. per hour.

Applicants must have served an apprenticeship as a motor fitter and be capable of carrying out all types and general repairs to motor vehicles.

(5) Fitter/Welder. The rates of pay will be in accordance with those laid down by the Joint Negotiating Committee of the Local Authorities Services (Engineering Craftsmen), at present 3s. 11d. per hour.

Applicants must have served an apprenticeship and be capable of welding by oxy-acetylene and electric arc process, ferrous and non-ferrous metals including castings.

Appointments Nos. (2) and (3) will be pensionable contributions at the rate of 5 per cent. being paid under the Local Government Superannuation Act, 1937. Appointments Nos. (2) to (5) will be terminable by one week's notice on either side. The successful candidates will be required to pass a medical examination.

The present hours for a normal working week for appointments Nos. (2) to (5) are forty-four, and the general conditions as to holiday and sickness are governed by the Joint Negotiating Committee for Local Authorities Services (Engineering Craftsmen).

Applications, stating age and experience, and the names and addresses of three persons to whom reference can be made, must be addressed to the Borough Engineer and Surveyor and delivered not later than 10th June, 1953.

In all cases canvassing, either directly or indirectly, will be deemed a disqualification.

Dated this 11th day of May, 1953.

LEONARD WORDEN,
Town Clerk.

Town Hall,
Hendon, N.W.4. E[illegible]

MID-NORTHAMPTONSHIRE WATER BOARD

ENGINEERING ASSISTANT

Applications are invited for a temporary post of ENGINEERING ASSISTANT for work in the Board's Northampton office, in connection with the design of new works. A knowledge of reinforced concrete detailing is required.

The post is subject to the Local Government Superannuation Acts, and may be expected to last three or four years. Salary, £800 per annum.

Applications, accompanied by the names of two referees, should be sent to the undersigned not later than 6th June, 1953.

E8687 LEONARD H. BROWN,
Engineer and Manager

RAUCEBY HOSPITAL, SLEAFORD

ASSISTANT ENGINEER

Applications are invited for this post from persons who have completed practical training in Mechanical Engineering and hold approved qualifications. Salary scale £425 by £15 by £20 to £525. Unfurnished house available. National Health Service Superannuation Regulations and conditions of service apply. Applications, giving full details of qualifications and experience, must be received by the Group Secretary, Lincoln No. 3 Hospital Management Committee, Harmston Hall, Lincoln, within 14 days of this notice. E[illegible]

THE ENGINEER

MAY 22, 1953

Research and Industrial Efficiency

IN his presidential address, delivered at the annual conference of the Institution of Professional Civil Servants on Monday last, Sir Richard Redmayne commented on what he called the "wider issues of the economic standing of our country." Britain, he said, had built up a reputation for industrial efficiency which it could not afford to lose, but in the circumstances of 1953 that position could be maintained only if research and investigation were given a foremost place in our economy. On basic research, Sir Richard continued, the recent report of the advisory council of the Department of Scientific and Industrial Research had spoken with an emphasis most unusual from a body of that character, an emphasis which it was incumbent upon the statesmen of this country to notice. Not only, Sir Richard added, had there not been the expansion that was envisaged for the D.S.I.R., but there had, in fact, been a cut, for the face value of present-day estimates was no indication of real value. Sir Richard went on to say that it was the unfortunate fact that important contracts had been lost to Britain through the absence of a centre with facilities for basic research and experiments with models on coast erosion and accretion, the effect of dredging and drainage schemes on estuaries and rivers, and the design of dock and harbour works to avoid silting. How, he asked, could it be an economy, bearing in mind the obvious needs of this country to expand its exports, when contraction of scientific effort led to this result ? Economy that was real economy was something to be welcomed, but, Sir Richard observed, economy that was the restriction of important and necessary work leading to the development and strengthening of the country was a grave waste.

Underground and Surface Coal Gasification

A REPORT has been published by the Organisation for European Economic Co-operation, Paris, of the findings of a Technical Assistance Mission which visited the United States early last year. The underground gasification of coal forms the subject of the first part of the report, and in a foreword emphasis is placed on the social and economic importance of this process. It reviews the experiments on underground gasification carried out in Europe and the United States. It describes the technical problems of underground gasification, summarises the results achieved, outlines the programme of future experiments proposed by the various countries, and draws conclusions from the discussions of the experts at the first Congress on Underground Gasification at Birmingham, Alabama. Various technical aspects of underground gasification are considered in the report, such as contact between the gas flow and the coal, preparation and firing of the workings, progression of the zone of combustion, reversal of circulation, thermal balance, gastightness, nature of the comburant (air or oxygen), and preheating of the air. A description of the electro-linking system used in the American experiments is also included. Chapter II deals with the processes of gasifying mined coal which are in use in Europe or of which the experts received practical demonstrations at a number of research centres and pilot plants in the United States. The chapter also shows how various gas producers work and describes the results achieved. Finally, the experts express their views on the Fisher-Tropsch and hydrogenation processes for synthesis.

The British Pressed Metal Industry

THE report has now been published of the team from the American pressed metal industry, which paid a visit to this country in 1951 under the auspices of the Anglo-American Council on Productivity and the Economic Co-operation Administration. The objects of this team were to report on means of increasing productivity in British stamping plants and to determine what use had been made of the information obtained in the United States by the British Productivity Team and presented in its report. The team also proposed to take back to the United States any information likely to be of use to the stamping industry in that country. The team visited the works of thirteen British companies. It states that specific comparisons between British and American methods and equipment were made impossible owing to the difference in philosophy, both economically and politically, between the two countries, and the fact that this country had been through two devastating wars in twenty-five years. A great similarity was noted between the buildings and equipment used in the two countries, but it was found that a far greater use was made of jigs, fixtures, &c., to reduce the use of manpower in the United States. The lack of standardisation in this country is criticised in the report and the team considered that, although the manufacturers complained of this, there was no indication that a firm stand had been made with customers on the matter. There was also a need on the part of management in this country for cost-consciousness, the recognition and adoption of improved methods of materials handling, line production methods, and better co-operation between safety engineers and production personnel.

A Collection of Letters to Sir William Siemens

LAST week the Institution of Electrical Engineers was presented with a volume containing printed copies of more than 250 letters (and facsimile reproductions of twenty-two of them) written by well-known men of science and letters to Sir William Siemens. The presentation was made at an informal ceremony after the annual meeting of the Institution of Electrical Engineers, when the volume was handed by Sir George H. Nelson to Colonel B. H. Leeson, the president of the Institution. The originals of the letters were bought by Sir George Nelson, who is chairman and managing director of the English Electric Company, Ltd., from Mrs. Mildred Wells, a first cousin of Lady Siemens. This collection of letters, together with a short biography of Sir William Siemens written by Mr. W. H. Kennet, has been bound into two volumes. It was for the benefit of engineers interested in the life of Sir William Siemens that the third volume was made and presented to the Institution of Electrical Engineers. Each of the three volumes is hand bound in red Cape morocco by Messrs. Sangorski and Sutcliffe, the bindings being hand tooled and gilt embossed. The printing was done by the Oyster Press, of Colchester, and the twenty-two facsimiles included in the third volume were reproduced in collotype by Mr. W. Butfield, of Chiswick Press. Not many of the letters are of deep scientific significance, but they do reveal something of Sir William Siemens's personality and interests. There is, for example, the appeal for information from Professor Max Müller, Professor of Comparative Philology at Oxford University, who wrote, on February 17, 1873 : "To-day the Prince of Schaumberg asked . . . about a smoke consuming locomotive ! I really don't know anybody who could help me and in my helplessness I address you now. It appears to me that he wants to know *where* this smoke consuming locomotive is in existence, *how* the same meets its requirements, which factory produces them, to *what* price and at *how many* horse power ?" More practical, perhaps, is the request contained in a letter dated February 27, 1863, from the then Chancellor of Oxford University : "Sir, The Bodleian Library at Oxford is heated by steam. We are not quite satisfied as to the entire safety of the process and should be glad if you could visit the library and give us a report."

Launch of P and O Liner "Arcadia"

ON Thursday, May 14th, the S.S. "Arcadia," the new liner which John Brown and Co., Ltd., is building for the Peninsular and Oriental Steam Navigation Company, was launched from the builder's Clydebank shipyard and was named by Mrs. D. F. Anderson, the wife of the deputy chairman of the owning company. The ship is the second vessel of that name to be built for the owners, the first being one of the "Jubilee" class of 1887 which was broken up after the first world war. An interesting link with the earlier vessel was the presence at the launching ceremony of two officers who had served in her, namely, Captain G. S. Stable, who retired as commodore of the P and O fleet in 1951 ; and Mr. H. Livingstone, at present serving as chief engineer of the "Himalaya." When completed, the new ship will resemble closely the "Himalaya" in external appearance, except for the funnel, which has been specially designed to avoid smuts and soot falling on the decks, and the addition of a mainmast. The ship has a length overall of 718ft by 90ft 6in beam, a load draught of 30ft 3in and a gross tonnage of 28,000. A total of 670 first-class passengers will be carried in one, two and three-berth cabins, while the tourist class accommodation will take 735 passengers in two, four and six-berth cabins. For both classes of passengers spacious public rooms will be provided and an extensive air conditioning system, while Denny-Brown stabilisers will be fitted. The ship will be driven at a service speed of 22 knots by two sets of geared turbines designed to develop a maximum of 42,500 s.h.p. when taking steam from three Foster-Wheeler boilers, each of which is capable of producing 165,000 lb of steam per hour.

Institution of Engineers-in-Charge

THE forty-eighth annual dinner of the Institution of Engineers-in-Charge was held at the Holborn Restaurant, London, last Friday evening, and brought together a large company of members and guests. The president, Sir William Stanier, F.R.S., was in the chair, and was ably supported by Mr. F. E. Shaw, the chairman of the Institution's Council. The principal guest was Sir Harold Roxbee Cox, chief scientist of the Ministry of Fuel and Power, who proposed the toast of "The Institution." Sir Harold said that engineers were passing through some difficult times ; they were busy making armaments and they had to be busy making machinery for overseas. But, he continued, it would be a great pity if the engineering industry had no new products to make, for new products, he was convinced, were the key to the industry's future success. It was essential, Sir Harold added, to make sure that this country's tremendous capital of scientific and engineering knowledge was used to the very best advantage. After a reply by the president, the toast "Our Guests and Friends" was given by Mr. Robert Chalmers, the immediate past-president. In a special reference to absent friends of the Institution, Mr. Chalmers conveyed greetings from several past-presidents, notably Sir Alexander Gibb, Sir William Larke and Mr. Loughnan Pendred. Dr. S. Livingston Smith acknowledged the toast on behalf of the guests. The final toast of the evening—"Our President"—was proposed by Mr. Shaw, was most warmly accorded, and was graciously acknowledged by Sir William Stanier. Following the Institution's custom at its annual dinner, there was an excellent vocal and instrumental entertainment to add to the pleasure of the evening.

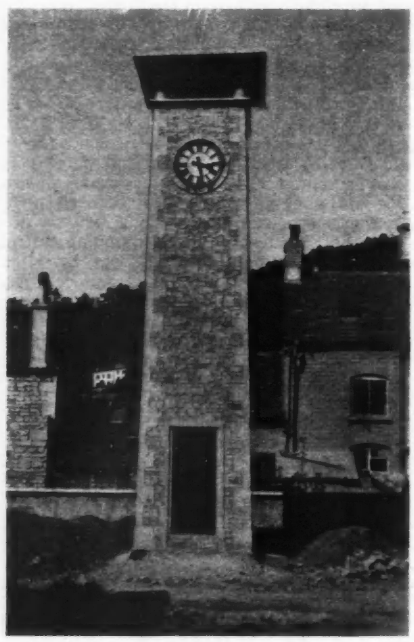
The Clock Tower at Nailsworth

By T. R. ROBINSON, F.B.H.I.

A clock tower of particular interest has been built at Nailsworth in Gloucestershire, to replace the old wooden tower in the churchyard, which has for many years been one of the architectural landmarks of the district. The belfry of accepted design has been replaced by a tower having a sounding board at the top and having the bells arranged below with their mouths facing upwards.

A UNIQUE clock tower, with a belfry scientifically designed to give the correct sound distribution to suit the surrounding neighbourhood, has recently been brought into service as the War Memorial of the town of Nailsworth, Gloucestershire.

The tower is situated at the bottom of a valley, closely surrounded by shops and residences, and its very unusual construction was adopted to prevent the sound of the bells from giving any annoyance to those living near by, and, at the same time, to ensure that the quarter chimes and hour striking would be audible to residents on the hill slopes above the town. This has been achieved by planning the interior of the tower and the belfry openings at its top in such a manner that the main volume of



The New Clock Tower

sound from both quarter and hour bells is directed upwards and away from the tower at a predetermined angle, instead of being allowed to spread away in all directions in an uncontrolled manner.

When designing this tower, the architect, Mr. Peter Falconer, made good use of the results of some modern research into the distribution of sound volume around a bell, and much of the success of the Nailsworth tower is due to the technical information available on this point. Another factor that proved of great assistance was the small amount of space required by the modern automatically wound clock mechanism. This enabled a clock possessing ample power to be installed in a small clock room at the base of the tower, and obviated all weight chutes, lines, pulleys and similar components.

The tower is constructed of Cotswold stone, and, as can be seen from the photograph above, its external appearance, though plain, is distinctly attractive. With an overall height of approximately 30ft, the tower has a side width at ground level of 7ft 6in. On each of the four sides and at a height of about 24ft is a 4ft 3in diameter skeleton dial, the spaces between the figures and minute marks and at the centres being glazed with opal glass to provide for internal illumination at night. Care was taken to select the proportions of the numerals and hands to give maximum legibility, and the size of the dials is slightly larger than is given by the usual rule of "1ft of diameter for every 10ft of elevation" for the same purpose.

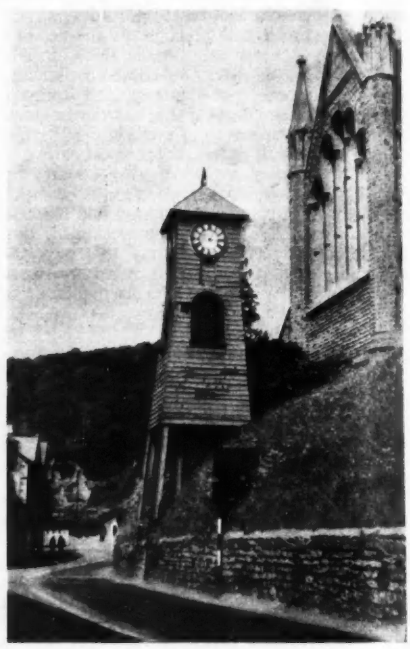
To provide means for directing the sound of the bells, the interior of the tower is divided into two compartments as shown in the drawing opposite. The lower compartment houses the clock mechanism, switchgear, fuses and the time-switch controlling the dial lamps. The upper compartment comprising the whole of the rest of the internal space of the tower, right up to the belfry openings, contains the bells, their hammers and crankwork, and, towards the upper end, the bevel gearing and the shafts leading to the hands of the four dials.

At the extreme top, the tower is surmounted by a reinforced concrete sounding board, which is really a two-stage inverted cone, resting on four pillars of oval section, set at the corners of the tower walls. The tops of the tower walls themselves are curved to a form corresponding largely with that of the inverted cone, so that the spaces between the curved wall tops and the sounding board form sound channels inclined upwards at about 10 deg. above the horizontal. This formation of the belfry openings gives quite effective control of the volume and distribution of the sound of the bells. The choice of pillars of oval section to support the sounding board was made in order to reduce reflection of sound, even from these relatively small surfaces.

The location of the bells is as novel as the belfry that contains them, for they are bolted in a "mouth upwards" position to girders spanning the tower walls at a level only about 2ft above the floor of the belfry. This, of course, is a complete reversal of normal practice, for bells are usually placed as high up as possible, and with their mouths downwards. The diagram showing the area of maximum sound volume from a bell indicates the reason for this "inverted" mounting, and it will be apparent that the sound of the bells in the Nailsworth tower will be directed upwards, and then reflected, or "bounced," by the sound channels at the top, so that it will emerge from the belfry at a definite angle. In this way, the main volume of sound from the bells is directed up, above the roof level of the surrounding houses and shops, and away to the more distant hillsides.

There are three bells, two for the "ting-tang" quarters, and the third for the hour. The quarter bells measure 12in and 15in respectively across their mouths, and the hour bell has a mouth diameter of 25in. The quarter bells are new and are tuned on the "five-tone" harmonic principle which gives a very pleasing musical effect. The hour bell, which was formerly in use in the unusual old clock tower that formerly stood in Nailsworth, was cast in 1794 in the famous Rudhall foundry. The unusual position of the bells rendered it necessary to install specially designed hammers, which are mounted above their bells, and strike on the inside of the sound bow when they fall, instead of on the outside in the usual way. Although this method of striking was adopted largely because it was the most convenient one, it also accords with modern methods, for research has shown that the tone of a bell is better, and its volume greater for a blow of any given force if it is struck on the inside rather than the outside of the sound bow.

The clock mechanism is of modern unit construction, the timepiece, chiming and striking units being provided with separate frames which can be placed in the most convenient positions in the clock-room, and linked up electrically. The automatically wound timepiece is of simple design and can be seen in one of the illustrations. It has a flat, cast iron bedplate, which supports the rewinding motor and its switchgear, and two "A" shaped castings in which are



The Old Clock Tower

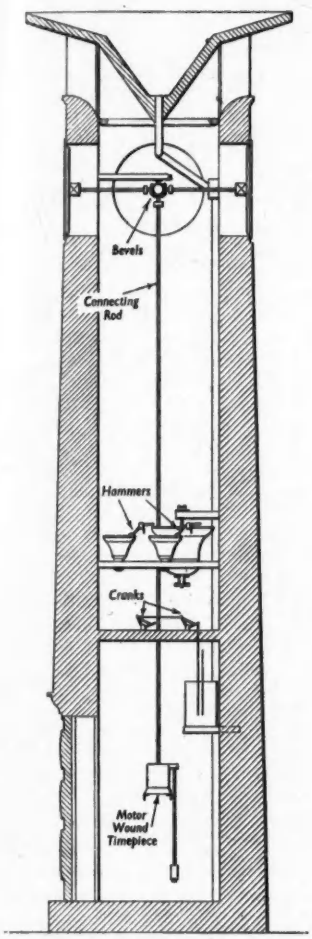
mounted the gunmetal bushes for the spindles of the time-train wheelwork. The train is made up of two wheels and pinions, and the escape wheel, the latter being of the "pin-wheel" form. This escape wheel is of unusual design in that it is a very light steel pressing, with round steel pins riveted into its rim. This form of wheel is lighter than one of gunmetal, and its pins have been found to wear the pallets less than bronze pins, and to be less liable to become loose.

The pendulum, which makes one swing per second, is fitted with a wooden rod and a cylindrical bob, and it is firmly suspended from one end of a heavy bar that spans and unites the two "A" castings, and so forms a rigid support.

As a safety precaution, the crutch of the pin-wheel escapement is fitted with a special form of impulse pin, which normally rests in a "V" notch in a bracket on the pendulum

rod, but trips out if overloaded, and so prevents damage to the escape-wheel pins.

The automatic winding attachment is of Huyghens endless chain design, which enables winding to proceed without any interference with the timekeeping action of the clock mechanism. The switching of the winding motor is controlled by the descent and ascent of the clock weight, acting through two small, unequal weights attached to the ends of two lengths of light chain. The other ends of these two chains are attached to the rim of the twin-grooved switch-operating pulley, and part of each chain is then coiled around the pulley so that the



Arrangement of New Clock Tower

weights hang from opposite sides of the pulley.

The heavier of the two small weights rests in a cup fixed on the side of the clock weight, and, as the latter descends, falls with it, causing the lighter weight to rise. At a predetermined point, this action trips the switch of the winding motor, and starts the winding operation.

Winding then proceeds until the raising of the clock weight and the heavier switch weight allows the lighter switch weight to descend far enough to trip the switch back to its "off" position. The cup-and-ball assembly is used in place of the direct attachment of the switch chain to the clock weight in order to guard the switch mechanism against damage if the winding motor current should fail, and so allow the clock weight to descend further than its normal lowest point.

The winding motor is of about $\frac{1}{16}$ h.p., and it is linked to the winding sprocket of the roller chain supporting the clock weight by a totally-enclosed worm reduction gear, running in an oil bath.

The timepiece drives the hands of the four dials through a pair of bevel gears, one of which is mounted on the "one rotation per hour" spindle of the clock train, and the other on a short vertical spindle. This vertical spindle is coupled through a universal joint to a long vertical shaft, which leads, in turn, to a central "four-way" bevel gearing fixed at the level of the dial centres. This unusually straightforward arrangement, without any intermediate bevel gearing, is one of the incidental advantages afforded by the almost clear upper compartment of the tower.

The spindle on the timepiece which drives the hands also controls the letting off of the quarter chiming and hour striking units through low-voltage trip circuits, which are closed at the appropriate instants by switch levers actuated by cams on the timepiece spindle.

The chiming and striking units are both motor driven, and are very similar in general design. In each, the motor, centrifugal clutch and enclosed worm-reduction gear is identical, and it is only the hammer lifting cams and their levers that are modified to suit the special duty of the individual unit. The quarter chiming unit has, of course, two cams, and the hour striking unit, one cam and the lifting levers are similarly arranged.

The letting off of the units through the closing of the low-voltage trip circuits is actuated by a simple mercury-tube switch mounted on each unit. The mercury tube is mounted on a rocker arm, which is tilted to its "on" position electromagnetically by the closing of the low-voltage circuit concerned. Once this operation has taken place, the unit continues to run until the mercury switch is tripped back to its "off" position mechanically by the action of a count-wheel mechanism, which is fitted to each unit to give correct control of the sequences of chiming and striking.

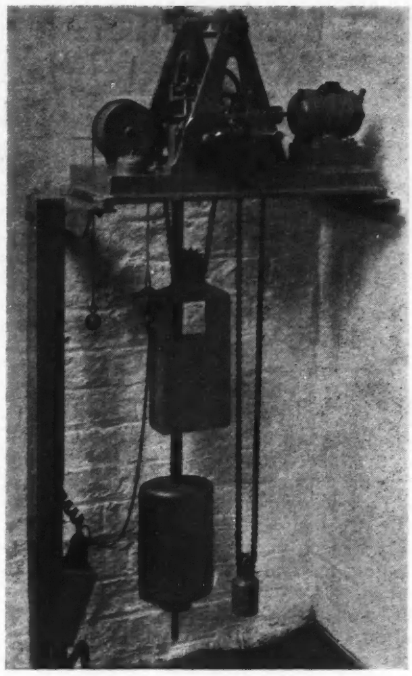
This count-wheel mechanism consists of a ratchet wheel, which is rotated, step by step, by the action of small cams on its associated unit, and, by means of suitably spaced pins inserted in its rim, causes the switchgear to break the circuit of the driving motor concerned as soon as the correct "quarter" or "hour" has been sounded. The chiming and striking units at Nailsworth are mounted on wall brackets, and the timepiece rests on two girders spanning the tower walls. This arrangement gives good accessibility for servicing, and easy regulation and adjustment of the timepiece.

As previously mentioned, the bell hammers are of unusual form. Their shanks and tails are in one piece, and the hammer heads are spherical. Coil springs are used for the buffering of the hammers, and adjustment of these springs to maintain correct clearance between the hammer heads and the bells is easily made by the placing of shims on the spring-locating pins.

Since they have been brought into use, both the clock and its tower have proved very satisfactory. The sound-directional design of the belfry is notably successful, for the volume of both the quarter and hour bells is quite moderate when heard near to the tower, but is also clearly audible right up the slopes of the surrounding hills.

So far as is known, the Nailsworth tower is the first that has been designed to take advantage of the differing zones of sound volume existing round a bell, and it is impressive to find the result so consistently satisfactory.

The clock mechanism was constructed and



Auto-wound Timepiece Movement

installed by Gillett and Johnston, Ltd., of Croydon, who also cast and tuned the two new quarter-chime bells, and rehung the old hour bell. It is a point of some interest that the old tower, which formerly contained this Rudhall bell, was also unique in its way. It was erected in 1898 in the churchyard of the then new St. George's Church, to form a "temporary" home for the clock displaced from the tower of the older church, and, as the tower of St. George's Church was never completed, it remained in use until it was demolished after the completion of the new clock tower. The old tower was of wood, and, as our illustration of it shows, its strange appearance quite justified its local title of "The Clock on Stilts." Even after the erection of the new tower was decided upon, the preservation of the old one was considered, but it was found to be in such a dangerous condition that its demolition could not be avoided.

Launch of Orient Liner "Orsova"

THE new Orient liner "Orsova" was named by Lady Anderson, the wife of the chairman of the Orient Steam Navigation Company, Ltd., when the ship was launched from the Barrow yard of Vickers-Armstrongs, Ltd., on May 14th. The ship, which is of all-welded construction, will present a profile which differs from the orthodox, in that no masts will be fitted and all navigational equipment will be carried by a large single funnel of inverted flowerpot form. A total of 685 first-class passengers will be accommodated in single and two-berth cabins; two, three, four and six-berth cabins will provide accommodation for 813 tourist-class passengers, while comfortable quarters will be provided for the crew. The ship has a length between perpendiculars of 668ft by 90ft 6in breadth moulded by 50ft depth moulded to "E" deck, and a draught of 30ft 9in. A service speed of 22·5 knots will be maintained by twin screws driven by Parsons geared turbines of Pametrada design, developing a normal power of 34,000 s.h.p. at 130 r.p.m. of the propeller, and taking steam at a pressure of 500 lb per square inch and a temperature of 800 deg. Fah. Three Foster-Wheeler controlled superheat boilers, fitted with economisers and air preheaters arranged to burn oil fuel under a balanced system of forced draught, will supply the necessary steam.

The Training of Engineering Designers

By PROFESSOR EWEN M'EWEN, M.Sc. (Eng.), M.I.Mech.E.

In this reprint of an informal lecture that the author presented to the North-Eastern Branch and North-Eastern Centre (Automobile Division), Institution of Mechanical Engineers, on April 22nd, the point is made that insufficient attention is given by universities to the training of designers. It is recommended that engineering undergraduates should undertake real design work under the supervision of members of the university staff who themselves practice as consulting engineers, and that such men should be valued as highly in the universities as the research worker and the mathematical engineer.

DESIGN is very much in the hands of the few and even in design departments it is only carried out by part of the staff part of the time. It was, for instance, at one time the current jibe against the Department of Tank Design, in which I was then serving, that although we were involved in research, development, testing, modification and rectification, the one activity notably absent was design. One day it was decided to supply this omission and the result was the "Centurion," but the main point remained true, that design was but a small part of the manifold activities of the department.* A further oddity was that a design officer might be employed on any of these activities but the one thing he was not expected to do was to lay pencil to paper and draw, that being the private preserve of a lower order, the draughtsman.

Why should it be *infra dig* to draw oneself ? We all say, with varying degrees of concern, that it is difficult to get good draughtsmen nowadays ; those of us who have left the drawing office deprecate the abilities of our successors : and those who are still in try to get out as soon as they can. The drawing board is a symbol of serfdom. The same tendency is notable in the way that the engineer who wants to get on financially leaves engineering for management as soon as he can and looks back with pity and perhaps condescension on those who can still recall off-hand the numerical relationship between torque, speed and horsepower. Of course, I do not expect the general manager to have a private drawing board in his inner sanctum ; but I think the chief engineer might, and the chief designer most certainly should.

The ordinary technical training of the engineer equips him with an armoury of analytical weapons with which to attack the technical problem which has been precisely formulated either in terms of an examination question or of a project for experimental investigation. But in fact the most difficult part even of analysis of real situations is the formulation therefrom of a problem sufficiently precise to be successfully attacked and sufficiently complete and representative for the solutions to be valid and useful. That such circumscribed problems and projects have value is not in question, but unfortunately the idea is abroad that the man who can solve them is trained. They are, of course, comparatively easily devised, and as a busy departmental head I must confess that this is a real attraction ; to devise more realistic assignments is a much heavier burden on the staff in research and investigational work, and is nearly impossible within the limitations of the examination time-table.

In general, analytical problems have unique solutions although there may well be many ways to achieve them. Problems of synthesis, however, have in general an infinity of answers covering the gamut of excellence and with no readily assignable scale of merit. In view of the difficulty of posing such problems to the student with a fair chance of success, and the magnitude of the task of judging their attempts, we in applied science departments are understandably reluctant to make the attempt ; we might here profit from an examination of the methods employed in departments of letters or of architecture. Unfortunately, the engineer in training gets the idea that genuine engineering problems are of the analytical type and that the others are either not engineering or not worthy of the attention of a highly qualified technologist. And this must colour his attitude to the designer in industry. The designer is a man with a kink or flair, who devises and creates on paper things which are sometimes open to criticism when subjected to ruthless analytical examination, when the "engineer" can be smugly superior ; and are sometimes not, but as the designer is paid to do that, of course, no undue credit should be given him for not having made any error that his betters can see !

There is a current tendency to decry drawing office work in engineering curricula as a necessary evil to be got past as quickly as possible ; necessary only to ensure that the engineer will understand the drawings of others and be enabled to check that his own draughtsmen have correctly interpreted his instructions. The standard of draughtsmanship of many engineering graduates is lamentable and most would be put to shame by the second year architectural tyro. But mechanical skill with a pencil is not a dexterity to be despised ; an accurate and readable layout will save many mistakes and hours of checking. And having acquired the rudiments of draughtsmanship and the ability to interpret in drawing form a simple engineering computation too frequently the budding engineering graduate says a thankful farewell to the D.O. and takes himself off to "relax" with an electric calculating machine. The "degree design" is *démodé*, the discipline of having to produce a set of intelligible drawings in answer to a problem posed in general terms is decried as hackwork. Fortunately, this is not universally the case (e.g. I.Chem.E. Associate Membership Examination ; some degree courses), but design is seriously neglected in too many engineering schools. I do not suggest that we should follow the pattern of departments of architecture slavishly—do architectural students ever sleep ?—but the idea that the studio is the spiritual and physical home of the student between lectures might be paralleled by a D.O. which serves similarly, but in step with laboratories, as the receptacle for time not spent in formal instruction. All-night sessions with thermos flasks of black coffee may be misdirected enthusiasm ; but this is infinitely to be preferred to "brown bagging."†

If we are to teach design I shall undoubtedly be told that the problem is one of belling the cat. One of my colleagues argues that only a practising designer can teach design and that this means peripatetic visiting lecturers loaned part-time by local concerns ; Sir David Pye may be taken to share this view. But this is begging the question. First, will local concerns spare their best men consistently for the necessary time ? Does even the best designer in most undertakings get more than a very limited view, depending on the scope of that particular company ? Is not a consulting mechanical engineer's office much more likely to provide the necessary background of day to day, mundane, real problems in fair variety ? And why should the consulting engineer not be a full-time member of staff with a part-time consulting practice instead of vice versa ? This is the practice in architectural schools ; it is true of some members of staff in engineering departments in universities. I believe it should be much more common ; senior members of staff should normally practise in this way and the selection of juniors should be coloured by design ability and experience as well as by existing desiderata of academic training, production experience and research.

In the technical colleges there should be no difficulty in obtaining designers from local industry as part-time teachers of the subject and in fact the younger of them are frequently to be met with teaching the subject there at an elementary level. What is required is a new status for design which should rank as an art at least the peer of scientific and engineering subjects.

Sir David Pye, in the presidential address to which I have already referred, quoted the statement of the managing director of "a small works where you might say that the spirit of design was rampant" that he recruited his designers direct from school. It was well stressed at the F.B.I. Conference on "The Universities and Industry" (1952) that in the welfare state it is becoming positively difficult for a reasonably bright boy to avoid going to a university : he is drafted into higher education. Dr. Ashby, the Vice-Chancellor of Belfast, there gave the following figures :—

	1912	1951
Boys reaching eighteen	397,700	305,700
Number in top 9 per cent of intelligence (Honours degree standard)	34,200	27,500
Number in top 5 per cent (good honours)...	19,000	15,300
Number entering university	4,000	16,500

What this means from the point of view of training designers is that there will be less and less opportunity for employers to take bright lads from school and allow them to become infected with the design virus by propinquity with their best designers during the formative years of apprenticeship. More and more the requirement for such men must be met by men from the universities who must therefore be trained as such at college, at the "tech" whilst undergoing post graduate works training, or at the works during the same period.

It is, of course, tempting to say that design is a matter for the individual firm and that training in it should therefore be a responsibility of that particular employer, particular works or even specialised department. To this there are, it seems to me, four answers : first, is it not contrary to experience that designers must necessarily remain in the same undertaking or even the

* As is recognised in its current title of Fighting Vehicles Research and Development Establishment.

† At U.C.L. twenty-odd years ago a "brown bagger" was one who arrived at 9, attended such lectures and laboratories as were prescribed and caught the next bus or train home with his brown bag of books and notes. In my time we ran their trousers up the flag-pole.

same industry ? Is it not rather the case that a good designer of automatic wrapping machinery is soon at home with the specialised problems of textile machines or armament ? Secondly, Ian Hay once remarked that from a tripe-dresser you would only expect an exposition of the stereotyped methods of dressing tripe : too much inbreeding of design is stultifying. Thirdly, who is going to train the designers for the smaller undertakings who make up so large a part of industry and who at present, of course, recruit partly from the staffs of larger firms but largely from the odd lad with ability who enters by the gate which is closing, the bright lad direct from school ? Will they be able and willing to pay post-graduate salaries to graduates learning the rudiments of design from scratch ? And, finally, is it not really shirking the issue to lay it all on the employer ? Are we in the universities doing our job properly ? I fear that with the terrible additional responsibility of dealing with nearly all the best brains of the nation, we cannot escape the conclusion that design is a university responsibility, aided by the technical colleges. But it is the place of the universities to give the lead in this.

Of course, I do not suggest that all the best brains will find themselves at the university on a State scholarship ; the selection machine will naturally make some mistakes, probably most frequently at the stage of choosing the grammar school entry when the later maturer may find himself in the slower stream. And there is always a small supply of first-rate brains whose fathers have made the mistake of earning over £1500 a year and having two or three children, so that they cannot afford to send their sons to the university and earn too much to allow them to benefit from State scholarships ! For these, and for those able boys who will yet enter industry direct, I believe that the best training is apprenticeship, but apprenticeship to design and not necessarily to engineering. The embryo designer may not be much of a success in the planning department, nor vice versa. All apprentices should spend some time in the drawing office and those who show a flair for drawing should naturally gravitate back there and any spark of originality and creative ability should be a passport to the design office or the design end of the drawing office, when creative designs and constructional detail drawings are both produced in one place.

It is essential that the designer be given his proper status as the man who has the vision to see the way a functional requirement can be met. It is not the part-time product of inspiration in one whose main interests and function lie elsewhere but like any other worthwhile activity requires single-mindedness, devotion and industry. It is hard work. And it is madness that when a man shows that he has the flair and the vocation for design we so often find that he must leave it as a childish thing behind him if he is to make financial progress. This is not, of course, universally true and I am given to understand that the aircraft industry is particularly free of this folly ; nevertheless, the amount of design talent so sterilised annually is a precious asset wantonly wasted. If our engineering industry is to survive and lead the world we must recognise that the designer also is worthy of his hire.

Industry, then, must recognise its responsibilities to the designer by giving him adequate status and financial reward, and by encouraging the tyro to devote himself to it as much as it encourages the potential production engineer, instead of demanding from designers that high sense of vocation which overcomes all financial objections and which to-day the Church demands of her ministry. The final training can only be by doing, and the design office should be a goal for ambition.

The universities, for their part, must recognise that the designer is not the same species of animal as the analyst. The former creates, the latter criticizes or acquires knowledge which may guide the creative mind to new achievements. To do this, we must include substantial amounts of design work in the undergraduate engineering curriculum, and to make time for this we must sacrifice something else. The trend to four-year (three-year post intermediate) engineering courses has done something to lighten the time-table and the opportunity should be taken to give the art of design its proper status in the universities. But this should not mean just an addition to the time-table ; something may have to go out. There is a natural and deplorable tendency for us all to consider a man ill-trained if he is not well versed in the detail of our own speciality, and to judge his standard too much by the sum of his knowledge rather than his ability to apply principles and use the knowledge of others when the latter course is available to him.

We may well accept a lower standard in mathematics and mathematical engineering from the man who has real design ability ; this might, I suppose, be achieved by optional courses, but except in the last year of the course I should personally deprecate this solution which could be overcome in other ways, such as by allowing design ability to compensate for poor examination performance in a small number of other subjects. In any case, we must concentrate rather on training a man to think than on filling him with information, although I shall no doubt continue in Faculty meetings to press for the inclusion of as much time and material as possible in my own subject.

I conclude, therefore, by suggesting that the engineering undergraduate should undertake real design work leading to a degree design preferably under the supervision of members of the staff who themselves practise as consulting engineers ; that such men should be valued as highly in the universities as the researcher and the mathematical engineer ; that industry should honour and value its designers more highly, and that the problem is more important and the urgency greater than we have realised.

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Hanover Technical Fair

No. III—(*Continued from page 692, May 15th*)

WE continue herewith a description of some of the engineering exhibits which were to be seen at the Hanover Technical Fair this year.

VOLKSWAGENWERK G.M.B.H.

Among the smaller engines, the new " VW " stationary petrol engine designed for industrial uses, excited considerable interest. It is, we may recall, a fan-cooled, four-cylinder engine working on the four stroke cycle with two pairs of cylinders horizontally opposed. It has an output of 22 h.p. at 3000 r.p.m., with a maximum demand rating of 24 h.p. for short periods. The fuel consumption is 8·3 litres per hour at 3000 r.p.m. Our illustration, Fig. 14 shows a general view of the engine. The overall dimensions are : width 26·1in, length 29·3in, and height 26·5in. The cylinders have a bore of 2·95in and a stroke of 2·25in, the cylinder capacity being 69 cubic inches and the compression ratio 5·8 to 1. The weight of the unit with the standard equipment is 84kg, or about 185 lb. The fan drive, the air filter, the magneto and the speed governor can be seen in Fig. 14. Two of the cylinder heads can be seen below the cover plate and the exhaust silencer with its exhaust and outlet connections. Inside the fan casing there is an oil cooler. On the driving side are the silencer, the flywheel casing and speed reduction gear. The engine may be fitted with various kinds of drive to suit differing conditions.

The Volkswagenwerk G.m.b.H., of Wolfsburg, is represented in England by V. W. Motors, Ltd., Inego Place, 31, Bedford Street, London, W.C.2.

SALZGITTER MASCHINEN AKTIENGESELLSCHAFT

An improved form of the rotary disc loader built on the " Rosetz " principle, was demonstrated by the Salzgitter Maschinen Aktiengesellschaft of Salzgitter. It

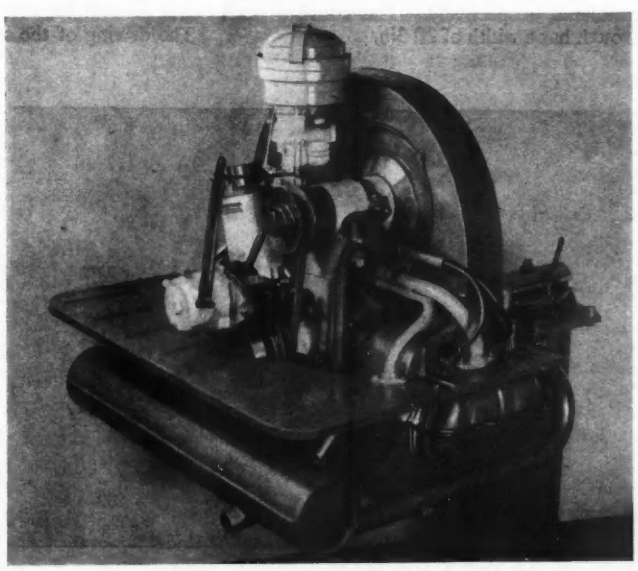


Fig. 14—Industrial Petrol Engine—Volkswagenwerk

is designed to load bulk material and maintain a constant flow with sizes from the smallest grains to pieces about 23in in diameter, the size handled being determined by the 24in diameter of the loading disc. In Fig. 15 we give a general view of the new loader and Fig. 16 clearly shows the arrangement of the loading disc and feed wheel. The loading disc is of steel with radial grooves and saw-like toothed edges. It is inclined slightly to the horizontal when in the working position and turns at a speed of about 20 r.p.m. The feeding element is a steel drum arranged at one side of the disc and driven by an electric motor, which feeds the material on to the conveyor belt. The delivered material ascends and is dropped on to a second conveyor belt, which delivers it into a wagon or on to a heap. The second belt can be swung through a radius of 180 deg. and it is balanced by a counter-weight which makes manœuvring easy.

Fig. 15—Rotary Disc Loader—Salzgitter

The loader is mounted on a chassis with a differential rear axle, balloon tyres and steering gear. Electric motors are used for the individual drives but where necessary a diesel engine driven generator can be provided, or the motion can be operated by compressed air.

The designed lifting capacity of the unit is from 120 to 250 tons per hour, depending on the nature and position of the material to be loaded. The complete machine weighs about 5 tons and has a total length of 42ft 7in. Its height is just over 11ft and the working height below the delivery end 9ft 2in, and 10ft 6in, at 15 and 20 deg. gradients, respectively. The conveyor belt trough has a width of 2ft 3in.

Demag Aktiengesellschaft

The stand of the Demag Aktiengesellschaft of Duisburg was dominated by the new "H6-B" level luffing crane illustrated in Fig. 18, one of a series of twelve now under construction for the Hamburg harbour board. The crane is electrically driven at 50V d.c. and has been designed to fulfil the following conditions. The lifting capacity at the maximum radius of 22·4 metres is 3 tons. The jib can be luffed under load down to a radius of about 7m. The rail gauge is 6m and the wheelbase 6·9m. A hoisting speed of 35m per minute with a load of 3 tons is provided. Slewing at full load is accomplished at 1·4 times each minute. The luffing speed is approximately 50m per minute and the travelling speed of the crane 18m per minute. As the illustration clearly shows, a three-legged construction is used for the gantry. The entire gantry structure is constructed of welded plates and the required stability is obtained by filling the legs completely or partially with concrete. Tests made by the harbour authority have shown that, provided the concrete is properly made, no internal corrosion of the steel takes place. The gantry travelling gear comprises an arrangement of three or four wheel boxes, one or two of which are fitted with the travelling drive.

The connection between the slewing portion of the crane and the gantry is made by a double ball-race ring bearing which gives internal access to the crane through the centre by means of access ladders and stairways. The enclosed driver's cab is designed to give a complete view of lifting operations. The driving of the crane is simplified by the use of the new Siemens-Schuckert crane-driving seat, in which all levers are directional. The jib is of plate construction, the jib chords being machine-welded hollow plate members with cambered walls to improve the buckling strength. A rope equalising luffing level system is adopted and the jib adjusting gear is of the segment-rack type. All the gears run in oil baths. The slewing structure of the crane is also of bent plate construction with two platforms. The upper one carries the hoist and the lower the slewing gear. The slanting wall of the upper part serves as a slideway for the jib balance weight. The lower part is fitted with an additional counterweight of

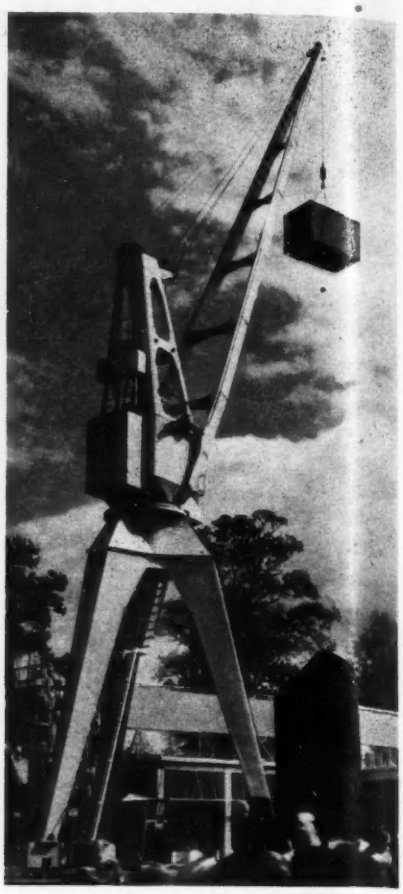


Fig. 18—Quayside Crane—Demag

Fig. 16—Disc and Feed Wheel of Loader—Salzgitter

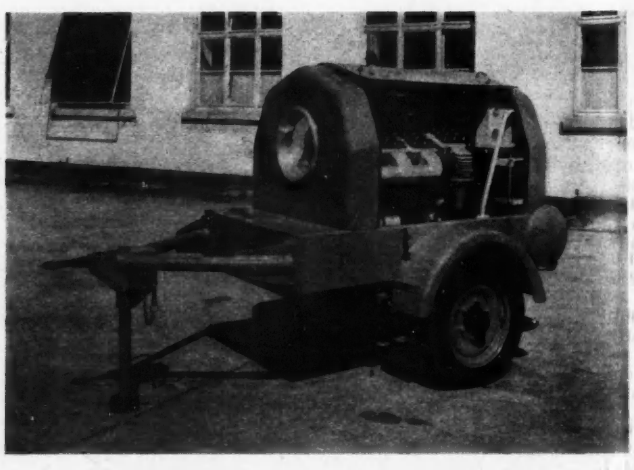


Fig. 17—Mobile Air Compressor Unit—Demag

scrap and concrete. The rope drum provides accommodation for rope sufficient for a 40m lift and all ropes and pulleys conform with the D.I.N. standards.

A new exhibit was the internal-combustion-engine-driven air compressor designed as a trailer, shown in Fig. 17. This "Moko 4·5" unit is driven by a "Modag" two-stroke, air-cooled oil engine with three cylinders having a 130mm bore and a stroke of 180mm, coupled in "V" form with three compressor cylinders, two low pressure and one high pressure, which are also air cooled. They have a bore of 130mm and a stroke of 203mm. The designed output of the set is 4·5 cubic metres at a pressure of 7 atmospheres when running at 1000 r.p.m. The unit is started by means of a Bosch electric starter.

The Demag company is represented in England by D. M. M. Machinery, Ltd., 119, Victoria Street, London, S.W.1.

Ardelt-Werke G.m.b.H.

About three years ago the Ardelt-Werke G.m.b.H. of Osnabruck and Wilhelmshaven Industriegelande West began the design of a crane for special uses in harbours not provided with quayside cranes. For this purpose a high lifting capacity with maximum lifting radius was required. For lifting heavy cases or goods with the crane hook, a capacity of 2 tons at a radius of 18m was provided.

The crane is mounted on a strongly constructed chassis, having single giant pneumatic tyres on the front wheels and double-tyred wheels on the rear axle, and is fitted with movable outriggers for the capacity above mentioned, but it can be used without outriggers for smaller loads.

Fig. 19—Crane for Harbour Work—Ardelt-Werke

Tests have been made in several seaports with this new design of crane and last year we inspected the first of its kind in the harbour at Bremen. In view of the good results which were obtained the Ardelt-Werke decided this year to build a similar crane of larger capacity, which is illustrated in Fig. 19 and was demonstrated for the first time at the Hanover Fair. This crane will handle goods with the crane hook or it can equally well be used for dealing with bulk cargoes for which a four-rope grab is used.

The principal dimensions and particulars of the two cranes are as follows. The smaller "20G" crane, has a capacity according to the design of the chassis of 2 to 6 tons, unsupported, or supported by outriggers, at a jib radius of 7m to 18m, and jib pulley heights above the ground of from 9m to 21·5m. The crane is suitable for both hook and grab lifting operations and it is mounted on a six-wheeled chassis, as illustrated. When travelling by road the top 12m of the jib can be folded down to reduce the total height of the crane.

The larger crane, illustrated in Fig. 19, travelled from the Wilhelmshaven works of the company to the exhibition stand. It has a designed lifting capacity of 2 to 6 tons, and it is fitted with adjustable outriggers. The lifting radius is from 8m to 18m and the height of the top pulley of the jib is from 8·5m to 20·5m. The chassis has been designed for heavy grab lifting operations. The motive power for the two cranes we have described is taken from a multi-cylinder diesel engine. For the smaller "20G" crane a three-cylinder Deutz air cooled engine is used and for the larger "30G" crane a six-cylinder engine of the same make. The road speed of these cranes is about 12km per hour. The tyres, we noted, are 1200mm "Continental" pattern, which are strengthened for crane operation.

(To be continued)

Iron and Steel Institute

ANNUAL GENERAL MEETING

No. III—(*Continued from page 694, May 15th*)

THE annual meeting of the Iron and Steel Institute was held in London on Thursday and Friday, April 30th and May 1st, with the president, Mr. James Mitchell, in the chair. During the latter part of Thursday afternoon the following four papers were jointly discussed :—

SPEED-DEPENDENT VARIABLES IN COLD STRIP ROLLING.

By R. B. Sims and D. F. Arthur.

Synopsis

The various ways in which the mill speed may influence the specific roll load and strip thickness in cold rolling are considered, and an experiment is described which allows the speed-dependent variables to be separated. In the experimental work, both steel and copper strip were used with thicknesses on entry between 0·050in and 0·010in, and a range of mill speeds between 10ft per minute and 300ft per minute. The strip lubricants were a commercial rolling oil and colloidal graphite. The results show that the variation of the coefficient of friction between the rolls and strip is the principal cause of load and thickness changes, and a relationship between the mean coefficient of friction and the speed of the mill is derived from the experimental results.

Methods of controlling the gauge of strip during periods of acceleration and deceleration are discussed, and it is shown that the methods of automatic control suggested by Hessenberg and Sims will maintain gauge to close tolerances over the speed range of the experimental mill.

PERFORMANCE OF HYDRODYNAMICALLY LUBRICATED ROLL NECK BEARINGS.

By R. B. Sims.

Synopsis

An experiment is described for measuring the mean thickness of the oil film in the bearings of a rolling mill during periods of acceleration and deceleration. The results include measurements made on the B.I.S.R.A. two-high experimental mill and on a large four-high cold strip mill. The change in film thickness with speed depends to some extent on the rolling load, and a hysteresis effect is shown when the mill is accelerated from cold.

The effect of changes in the thickness of the oil film on the gauge of cold rolled strip is discussed.

CONTROL OF STRIP THICKNESS IN COLD ROLLING BY VARYING THE APPLIED TENSIONS.

By R. B. Sims, J. A. Place and P. R. A. Briggs.

Synopsis

When a rolling mill is run at constant speed, errors in gauge arise from changes in hardness, width, and thickness of the incoming material and from variations in the rolling friction. The gauge of strip may also vary when the mill speed is changed.

An automatic regulator has been built to demonstrate on a pilot-plant scale a method of controlling the gauge of material cold-rolled in a strip mill. A measure of the departure of rolled-strip thickness from the desired value is obtained from the mill load and a correction is made by varying the applied strip tensions. The controller is described in the paper, together with a number of subsidiary circuits which make the system of control suitable for production mills.

Experiments have been carried out which show that the gauge of strip may be held to very close tolerances by this method.

WORKS TRIAL OF THE "T" METHOD OF AUTOMATIC GAUGE CONTROL.

By R. B. Sims, J. A. Place and P. R. A. Briggs.

Synopsis

Although a complete prototype of the tension method of the B.I.S.R.A. automatic gauge control had been built in the laboratory and had undergone successful trials, it was questioned whether the control would function satisfactorily at high rolling speeds and produce strip of good shape. To resolve these doubts a set of experiments was carried out on the four-stand four-high tandem cold mill at the Shotton Works of John Summers and Sons, Ltd.

Discussion

Mr. R. Cook (Steel Company of Wales, Ltd.) : If the ultimate answer to the problem of obtaining correct gauge can be found in automatic control, then it is something which should be followed to its ultimate conclusion. I speak solely from the point of view of a tinplate manufacturer and from the point of view of a five-stand tandem mill. One very important feature of a tinplate mill has been largely nullified under this control, namely, the screwdown. In tinplate production it is essential to have a flat and uniform strip to process, and owing to the variations which are encountered it is necessary to have the use of the screws at all times. We invariably correct a loose or wavy edge during the running of a coil by means of operating the inside or outside screw. In the method outlined by the authors the experiments gave an accuracy of approximately $\pm 0{\cdot}0015$in, which may well be suitable for sheet tolerances, but which would be unsuitable for tinplate manufacture ; so that until tinplate rollers are given evidence of the ability of this control to maintain gauge to a finer tolerance, in the region of $\pm 0{\cdot}0004$in, they will not be convinced that the application of this control would be beneficial to them.

Mr. P. E. Peck (British Thomson-Houston Company, Ltd.) : In the fourth paper, on page 358, the authors state that the speed effect of the mill at Shotton is very large. Can they give any figures about this ? What are the main contributory factors, and, of these factors, what is the percentage effect which the gauge control pure and simple can look after, apart from artificial feeds into the

system, such as the one for lubrication in proportion to the speed, and so on ? Reference is made on pages 357 and 358 to loss of sensitivity at low speed when the control is through the field of a motor. There are two aspects of this. There is the variation of sensitivity for various speed settings of the motor itself, due to the shape of its saturation curve, so that considerable changes in field current are required to produce a certain percentage speed change at the low speed compared with the top speed. The second aspect is that when running the field is set at some substantially fixed value and the speed is raised or lowered by the change of the applied voltage to the motor.

In order to change the torque of the motor to effect a control in tension it is necessary to change its back e.m.f., and to do that it is necessary to change its field current to alter the flux in the field. When running at reduced voltage and therefore reduced speed the field change to bring about a given voltage change must be greater the lower the motor speed. It requires a certain change of the voltage in the circuit to produce a certain change of current and hence a certain change of torque. Loss of sensitivity at low speed is due to the fact that the motor is running slowly, and a very big change of field is required to produce a given change of voltage on the armature circuit. On page 358 of the paper the inference is that the loss of sensitivity is due to the current being almost zero during retardation, but I think that the authors will agree that the loss of sensitivity is due to the reduction in speed, and in consequence the reduction in change of voltage in the circuit due to a given change of control on the field.

Mr. M. F. Dowding (Davy and United Engineering Company, Ltd.) : These papers represent yet another instalment in a serial story of rolling theory and gauge control in particular. If a criticism can be levelled at the producer of the drama it would be on the ground that his prologue has been unduly long and that the audience are now getting restive and want to see how the play will develop. The account given by Mr. Sims of the experiments carried out on the John Summers mill reveals how much hard work has been going on behind the scenes. If he had had his wish, he would no doubt have preferred to start with a simpler mill for his first industrial application of automatic gauge control, but the die was cast otherwise, and it is a great credit to the team that they did not flinch from the inherent difficulties of applying the A.G.C. system and the " T " method to a large tandem mill.

As is, I think, now generally known, as a result of negotiations between ourselves and B.I.S.R.A., the cloak of the producer has fallen very largely on the shoulders of my company. There are many difficulties in transferring the responsibility for something of this inherent complication, such as the development of automatic gauge control, from a scientific laboratory to an industrial firm. For example, if you have not a small back-room you have to build one, and one of the main problems is both to keep it small and to keep it back, and to ensure that the inmates of the room keep their feet on the floor. All these difficulties, however, are being largely solved by the fact that the first stage of this development from the laboratory trials to the industrial applications is being handled by a joint team formed between ourselves and the Association. It may be of some interest to know the programme on which we intend to proceed. We are starting with the development to the manufacturing stage of load meters and other instruments such as tension meters, including, of course, the gauge meter which Mr. Sims has touched on to-day. Once these are established as useful, sturdy and practical mill instruments, automatic gauge control in its various forms (on which research and laboratory trials will proceed simultaneously) will be ready for general application. It is hoped that the manufacture of the instruments themselves will be in progress in the early part of 1954, and the gauge meter at about the same time.

Mr. W. Spence (British Thomson-Houston Company, Ltd.) : The desirability of minimising the percentage of off-gauge strip rolled in continuous strip mills cannot be questioned. The economic aspect of the problem, however, is one which will undoubtedly loom large in the minds of strip producers. The tension method of gauge control, although it has been demonstrated successfully on a 1500ft per minute tandem mill rolling sheet gauges, is by no means free from disadvantages. The disadvantage of variable sensitivity with speed on the trial installation described by the authors is, of course, readily overcome on mills fitted with armature-circuit boosters or individual generators. Two main factors, however, seem to put the tension method at a disadvantage if we are considering its universal application.

First, on a modern high-speed mill rolling thin-gauge material the potential change of gauge due to the speed effect can be as high as 30–40 per cent, most of which develops in the later stands. To counteract such an increase of gauge by increasing the tension between, say, the last two stands, would call for an additional tension of the same order as the normal running interstand tension. Since the latter is usually quite close to the yield-point stress of the material, it follows that the strip would break in the attempt to hold gauge by tension, when coming down to threading speed. The authors seem to have recognised this possibility and fitted their equipment with an over-riding tension limit, but I wonder whether this does not virtually restrict the action of the automatic gauge control on a tinplate mill to the maintenance of gauge while running, a function which presents little difficulty to an experienced crew of operators. My second point is that since the speed effect is most evident in the later stands, gauge control by tension should properly follow the final stand. High tensions are undesirable between the mill and the wind-up reel in the interests of a good coil, so that if we are to use gauge control by tension after the last stand it would appear necessary to interpose a pair of puller rolls between the last stand and the reel, together with a drive motor of no small rating.

What I am leading up to is the expression of the opinion that what is really required is automatic gauge control by roll pressure on the hot mill, a problem on which the authors are also working. If the incoming band at the cold mill is of correct gauge from start to finish, then I suggest that the remaining need for automatic control of gauge of cold-rolled strip with varying speed can be adequately met by existing control methods applied to the stand drives. These can equally well be arranged to bring about an increase in interstand tension up to the safe limit as speed is reduced.

Mr. K. H. Slack (British Iron and Steel Research Association) : For the past two years I have been associated with Mr. Sims on the " S " method of control which he mentioned. I should like to compare the merits of this form with the " T " method. The tension method of gauge control, as pointed out in these papers, can be applied to only a few existing single-stand mills, since quite large tensions are required to cause an appreciable change in strip thickness. There are not many mills equipped with coils capable of applying high tension without damage or with the motor powers required for this duty. The control may be carried out on a tandem mill, and here there is the difficulty that in using interstand tension when all the stands are heavily loaded the correction is made in the penultimate stand, and therefore although the strip is on gauge in this stand variations will reappear, due to the effect of tension, on the last stand, though to a lesser extent, of course.

It will be realised that it is necessary, with this control system, to balance the servo while drawing the first coil through at a slow speed, and as soon as the strip is the required thickness the control is put into operation. If the production is in small batches of different gauges, however, the controller must be reset for every gauge. Its setting is somewhat inaccurate, since the strip is not measured in the roll, but some distance away, where the micrometer makes contact with the strip. A lag is therefore introduced into the system which could be troublesome. In normal production to-day the rolls must be adjusted until the strip is on gauge, and because the automatic balancing for the servo takes less than a second the " T " method does not delay production seriously. The " S " method, however, is far superior. The control consists simply of three indicating dials. The method does not rely on a contact micrometer. If the rolled strip does not correspond in thickness to the required value the rolls are repositioned automatically by the servo. Production is greatly speeded up and mill operation simplified. The other advantage of the setting method over the tension method is that it gives full gauge control from 3in to 6in from the beginning and to 1in from the end of the coil, whereas in the tension method a length of strip at least the distance between the rolls and the tensioning device is off gauge, and in addition there is the off-gauge strip produced before the contact micrometer indicates the correct gauge on the first coil of the batch.

The authors replied briefly to the discussion.

On Friday morning, May 1st, the first two papers presented for joint discussion were :—

THE QUENCH-AGEING OF IRON

By Anna L. Tsou, J. Nutting, and J. W. Menter

Synopsis

Optical and electron microscopes have been used to follow the metallographic changes occurring during the precipitation of carbon from a supersaturated solid solution in α iron over a range of ageing temperatures and times. An attempt has been made to identify the precipitates by electron diffraction methods. The results obtained show that precipitates form at random throughout the grains and then grow preferentially at the sub-grain boundaries ; at this stage they have the structure of ε iron carbide and are plate-like in shape. After ageing at 300 deg. Cent. the precipitates are still plate-like in shape, but have the normal cementite structure. Ageing at still higher temperatures results in preferential growth at the ferrite grain boundaries, and eventually cementite films are formed. The sequence of changes is very similar to that—previously deduced from X-ray evidence—for the decomposition of martensite.

Austenite has been detected as a grain boundary film, formed after quenching from 700 deg. Cent. an iron containing 0·026 weight per cent of carbon. Some of the factors responsible for its formation have been investigated.

EFFECT OF QUENCH-AGEING ON STRAIN AGEING IN IRON

By A. H. Cottrell and G. M. Leak

Synopsis

The dislocation theory predicts that the rate of strain ageing in iron should be proportional to the concentration of carbon and nitrogen in solution,

provided that an allowance is made for their different diffusion coefficients. This concentration can be varied by means of quench-ageing treatments given before the material is strain aged. These effects are examined experimentally from stress/strain measurements on soft iron wire. The limit of proportionality is a more sensitive index of strain ageing than the yield stress. As measured from the limit of proportionality, freshly quenched specimens strain age at about five times the speed of those quench aged at 120 deg. to 300 deg. Cent., and this difference is explained quantitatively. A theoretical estimate of the absolute solute concentration to give a certain rate of strain ageing is shown to be correct in order of magnitude. Specimens quench aged at 63 deg. and 45 deg. Cent. strain age too quickly to be accounted for by the equilibrium solubilities of carbon and nitrogen at these temperatures. An explanation is offered in terms of the small particle size of these precipitates, which increases the solubility. Because of its lower solubility and lower diffusion rate, carbon causes insignificant strain ageing in quench-aged material, compared with nitrogen. Only in the freshly quenched material is carbon more important than nitrogen.

Mr. B. B. Hundy (British Iron and Steel Research Association): I would like to confine my remarks to the paper by Professor Cottrell and Dr. Leak. One point that arises from this paper seemed to me to be most interesting. Apparently, when a freshly quenched sample of iron is strained, all age hardening due to quench-ageing is eliminated. This can be seen in Fig. 1 of the paper, where the rise in hardness on ageing of the freshly quenched and quench-aged material is about the same (about twenty points). This implies that straining prevents the precipitation of iron carbide or nitride, the solute atoms preferring to remain in solution—presumably forming clouds round the dislocations. This conclusion, of course, is in agreement with the results of Andrew and Trent, which are mentioned in this paper. One wonders, however, if there is a limit to this effect. If a steel containing, say, 12 per cent N was quenched and then strained 1–2 per cent, would this straining still prevent precipitation and hence eliminate the quench-ageing phenomena ?

It is interesting to compare this work with the earlier work of Davenport and Bain, who used the Rockwell hardness test to follow strain ageing. Like the present authors, Davenport and Bain tested material in the as-quenched and quench-aged conditions. The ageing treatment was seventeen hours at 100 deg. Cent. The agreement between the results of the two sets of investigations is very striking. In the earlier work quench-ageing apparently increased the strain-ageing time by about six to eight times (ageing at 20 deg. and 80 deg. Cent.), which figures compare closely with the figure of $\times 7$ quoted in the present paper. The time to reach the maximum hardness, however, was two to three times the time taken to reach the maximum yield point in the present work. I have also plotted some of Davenport and Bain's figures for strain ageing at 20 deg., 40 deg. and 80 deg. Cent. in terms of the parameter $(Dt/T)^{2/3}$. The scatter in these results is rather greater than in the present work, but it is possible to obtain a comparison of the initial ageing rates for the material in the two conditions. I calculate that the initial ageing rate of the freshly quenched material was about $4{\cdot}4\times$ that of the quench-aged material.

I would now like to ask one or two more detailed questions arising from this paper. Do the authors consider that comparable results would be obtained if the material in the two conditions had different grain size ? Say, for example, if the as-quenched material had a grain size of 8 and the quenched-aged material one of 5. What I am trying to get at is : is the rate of ageing at a grain boundary—considered as an array of dislocations—the same as the rate of ageing inside the grain (which was, I believe, the model used by Cottrell and Bilby in the derivation of equation 5) ? Next, I notice on page 303 the authors state that in fully aged specimens the upper yield stress is constant and is not preceded by any detectable plastic deformation. Is this to be expected ? I was under the impression that, according to the theory, some slight plastic deformation took place inside the grains before catastrophic yielding set in. Would the authors comment on this ?

M. C. Boulanger (I.R.S.I.D., France) : The paper is a very valuable one from a general point of view. From a quantitative point of view it is necessary to bear in mind the method by which the results were obtained at Chicago. The composition of the iron was not the same in the Chicago work, mainly by reason of its content of manganese, which would have an effect on the solubility of carbon and nitrogen.

Mr. W. P. Rees (National Physical Laboratory) : I shall confine the one or two remarks that I have to make to the paper by Tsou, Nutting and Menter. I wish to make one or two remarks about the finding of austenite in the grain boundaries of the material quenched from 700 deg. Cent. On page 167 the authors appear to think, from the calculation, that all the carbon and nitrogen which would not be in solution at 700 deg. Cent. had migrated to the boundaries. I do not think that that can be sustained, because the figure of the solubility at 700 deg. Cent. has been largely determined by the experiment of heating carbon steels and quenching them. At the beginning of the paper the authors say that that treatment did not get rid of the carbide particles. There is little doubt that all the carbon and nitrogen could not have migrated to the boundaries. I think they are right in believing that the austenite is essentially a nitrogen austenite and not a carbon austenite. The temperature is 590 deg. Cent. and they got the austenite even at 600 deg. Cent. It would be interesting to know if they could get it at 580 deg. or 550 deg. Cent. The finding of the austenite in the boundaries is quite important. It is an effect which in some ways is contrary to our conceptions.

As to the question of the possible migration of impurities to the boundaries, in work at the National Physical Laboratory on high purity irons we have shown, in a paper published by the Institute, that oxygen appears to migrate to the boundaries ; not as a discrete phase—it cannot be seen by ordinary photographic methods—but its presence is shown up by a very marked effect on the strength of the grain boundaries. We have found similar effects in iron-nitrogen alloys and iron-phosphorus alloys. We have not detected these elements on the boundaries, but we can show their effect on the strength. The metal becomes quite brittle. This is quite a common effect and it is quite an important effect. Examples are shown in the brittleness induced by overheating in alloy forgings. Our old friend, temper brittleness, also appears to be caused by this migration to the boundaries.

Another comment that I wish to make refers to the discussion in the paper about the possible sides which the carbon atoms can take up in the tetragonal martensite lattice and in the cubic α lattice. This is a very important thing ; it is not just of academic interest. I say that because, again quoting some of the work that we have been doing at Teddington, if you quench a low carbon iron containing 0·05 per cent of carbon to maintain the solution quenched from the austenite solution, the result is a material which, being a solute solution, is higher in hardness and strength than the ferrite, but unlike so many solutions and unlike the martensite solute solution where you have a very strained lattice, the increased hardness is not accompanied by a drop in ductility. In fact, the ductility measured by notched bar tests is increased by maintaining the carbon in solution. It is most likely that the position that the carbon takes up in the α lattice is responsible for the increased ductility of the solute solution.

Dr. M. L. Becker (British Iron and Steel Research Association): I may be a little sceptical, but in Fig. 3 (*b*) in the first paper with the micrograph purporting to show small platelets, I do not feel quite satisfied that we are necessarily seeing small plates, although I think it is very likely. It occurs to me that it might be worth while attempting to separate the carbides in the first place, the Σ carbide, and the hexagonal plates. It might be possible to separate them electrolytically and to examine their shape, either directly by means of the electron microscope or in some other way. The same would apply to the orthorhombic variety of iron carbide, which I think is definitely Fe_3, which bears tempering above 200 deg. Cent.

The presence of austenite has already been mentioned by Mr. Rees. It is very interesting, but it is not surprising to me that he found quite an appreciable amount of austenite in the boundaries in view of the treatments which were given and in view of the composition of the iron. I wonder whether the British Iron and Steel Research Association could not have given Dr. Nutting material slightly more suitable for his experiments than he evidently managed to get. The quantity of impurities is rather higher than we could have managed, particularly the nitrogen, and if a purer iron, such as that which the National Physical Laboratory make for us, could have been used and carburised—a further experimental difficulty—to about the same level, about 0·2 per cent, might that not have enabled Dr. Nutting and his co-workers to make some rather more specific conclusions from the results ? I dare say that his answer will be that it was not available at the time, but he can come back at me on that if he likes.

Dr. D. McLean (National Physical Laboratory) : There is one small experimental point which I wish to raise about the paper by Dr. Tsou, Dr. Nutting and Dr. Menter. I suggest that in this work there might be an advantage in using picral—picric acid dissolved in alcohol—rather than nitric acid dissolved in alcohol, as the etching agent. The effect of nitric acid is to produce large variations in the rate of etch of different ferrite roundations, so that carbide particles do not show up very well. If you use picric acid the different ferrite roundations are etched at nearly the same rate and any feature such as a grain boundary, a veining film or a carbide particle is revealed fairly well.

The observation of austenite films is an interesting one. It calls to mind an experiment by Carpenter, which is a very old one, but a very pretty one. In his studies of the transformation from austenite to ferrite pearlite he found that one austenite grain might start to grow towards the ferrite and that these would meet in the middle or at some other point. Shown in the centre is the region of high carbon content. He took a sample at above the eutectoid point and, on etching, it appeared to be martensite showing a high carbon content. It was the same sort of observation as Dr. Nutting has made inasmuch as it demonstrates the high carbon content. In the paper Dr. Nutting mentions that the austenite could

not be detected after slow cooling. However—at any rate in some cases—one certainly gets the films after slow cooling. In fact, their presence is reversible. If one cools at a moderate rate they are weakened in intensity and do not show up as much after etching. If one then slowly cools, they come up again. Therefore, whatever is producing them stays there or goes back again and does not disappear once and for all.

Dr. Becker cast doubt on the veracity of Fig. 3 (*b*) in the paper. Trotter, Clews and I did some similar work to this which was reported in the Institute of Metals electron microscope symposium. We aged a material and had sequences of photographs for increasing times at different temperatures. Although one could perhaps reasonably doubt the veracity of one photograph, seen in the context of this sequence, there could be little doubt that the appearance of a mottled structure was the prelude to a genuine precipitation, and for that reason I feel that Dr. Nutting's photograph is an accurate one.

Mr. P. Samuel (Hadfields, Ltd.) : I agree with Mr. McLean about picral being slightly more satisfactory in regard to its etching characteristic in revealing the grain boundary and veining films in these irons, although I think that nitric acid also has its possibilities. With regard to Dr. Becker's remarks, he may be interested to hear my own observation, as may Dr. Nutting, which is that in the absence of carbon you do not get these grain boundary ridges. I noticed that the grain boundary ridges were present in annealed Armco iron under a variety of conditions. If this film in the grain boundary is austenite and it has a separate phase, I am very curious to know why it does not transform to martensite and disappear that way. Why does it not spheroidise if it is annealed long enough at a low temperature ?

Dr. A. H. Cottrell (Ministry of Supply) : I should like to make an observation on the discussion on the paper by Dr. Tsou, Dr. Nutting and Dr. Menter. It relates to the question of the stability of phases at grain boundaries, particularly the stability of austenite. When considering this from the thermo-dynamics point of view, we should not overlook the work of Professor Cyril Smith in America on grain boundary energies. We can look to quite small effects to tip the balance one way or the other, and one of the small effects might be grain boundary energy. Smith shows that in many systems the energy of a boundary between two phases which are different is lower than that of a boundary between similar phases.

(To be continued)

The A.P.V. Works at Crawley

A new works on a 17-acre site has been opened at Crawley by the A.P.V. Company, Ltd., and the first major stage in transferring production equipment and personnel has been completed. In this new works the company is concentrating the productive capacity of four works and foundries widely spaced in and around London.

THE transfer of the manufacturing facilities of the A.P.V. Company, Ltd., to a new works in the new town at Crawley is now at an advanced stage and the productive capacity has been steadily increasing for some time. This company was founded in 1910 as the Aluminium Plant and Vessel Company, Ltd., by Dr. R. Seligman, and is now among this country's largest manufacturers of plant in stainless steel, aluminium and copper for the dairy, brewery, food, chemical and other industries. For some years it experienced difficulties in production as its manufacturing facilities were distributed amongst four separate factories. When the opportunity arose under the new towns development scheme it decided to lay down a new factory at Crawley, where all production could be concentrated in a single large works, which would also incorporate the aluminium and stainless steel foundries of a subsidiary company, A.P.V. Paramount, Ltd. A 17-acre site was procured and a new large works was so planned that all production could be integrated economically from an administrative viewpoint, whilst enabling the introduction of the most up-to-date manufacturing methods and modern working conditions.

Most of the buildings at the new works have now been completed and the plant installed under the first of the two major stages in which the move to the new premises was planned. The head office of the company and the coppersmiths' shops remain at Wandsworth at present, but they will be transferred to Crawley under the second stage of the move soon to be started.

On the new site the factory and the foundries, which cover an area of some 200,000 square feet, are arranged in two separate blocks, each with its own administrative offices, amenities, &c. The factory block, covering some 128,800 square feet, consists of five 475ft long bays and parts of three further bays to be extended at a later date. It is a welded steel portal frame structure providing large open floor areas and ample head-room. At present it incorporates the fitting, machining, press, polishing and assembly departments. The layout gives a general flow of work from the stores areas arranged across the bays at the front of the building rearwards, through the machining and other lines, to the assembly areas at the rear of the works. The photograph of the press section which we reproduce on this page is typical of the spacious machine layout in the factory.

The whole of the production, stores and assembly areas in the works are well served by overhead travelling cranes and there are broad gangways to give free access to trucks used for internal transport purposes. All machines and equipment are painted in accordance with the British Standard colour codes and the effect of these colours, with good lighting, ventilation, heating, and well spaced machines is to make the working conditions as pleasant as possible.

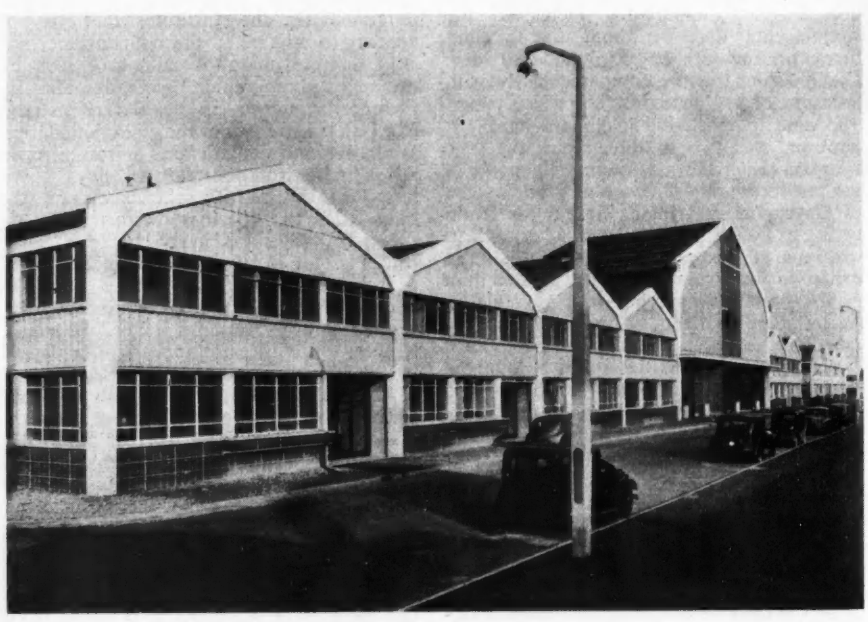
The new foundry consists of two large bays, 60ft wide and 250ft long, one of which is used for the production of stainless steels and the other for aluminium and copper-based alloy castings. The two sections are served by a common core shop and pattern stores, whilst they each have individual furnace lines, sand plant and fettling areas. It is not laid out for mass production of castings and most of the equipment can be readily rearranged in accordance with current production requirements or for the introduction of new plant as demand dictates.

An August sand treatment plant, which serves each of the foundry bays, is situated at one end of the building and is supplied with sand from large hoppers. The sand is mixed and milled in twin mills and after being tested for moisture, strength and permeability is distributed to the moulding stations by overhead conveyor belts. With this plant there is a core sand preparation unit, which feeds an adjoining core-making section complete with core blowing machines and batch and continuous drying stoves.

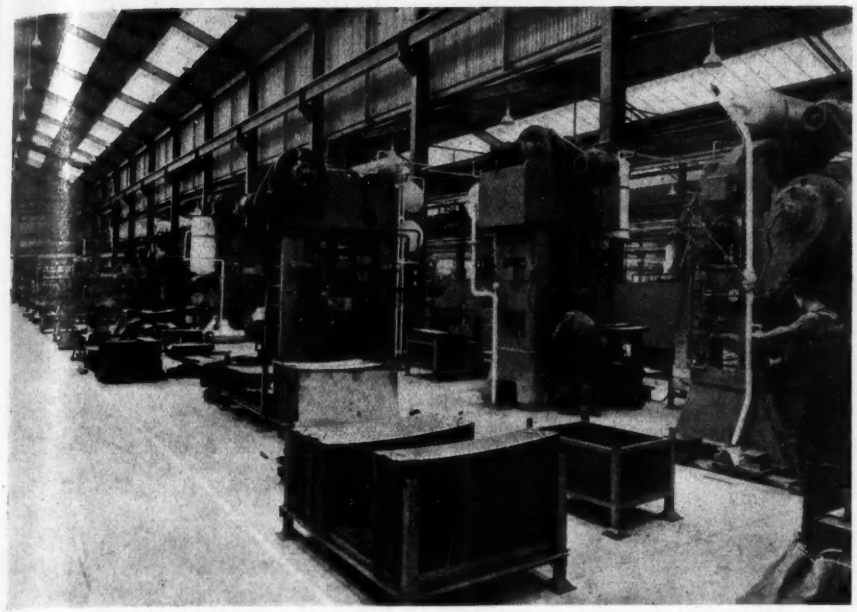
In the non-ferrous moulding bay the larger moulds are made in the floor area, shown in the foreground of one of our illustrations. The smaller moulds are prepared on machines arranged along one side wall and these moulds are closed on roller conveyors, down which they are moved to pouring stations. After they have cooled, the moulds are knocked out over grids, through which the sand falls on to conveyor belts and is returned to the sand preparation plant.

Seven oil-fired furnaces which supply the molten aluminium and bronze to this shop have an output of 4 tons a day, and they are arranged along the opposite wall of the building to the moulding machines. Two air compressors in a small room off the main bay provide air for all the pneumatic equipment and machines. The castings are cleaned in a shot-blast chamber before they pass into the fettling area at the far end of the bay.

In the adjoining stainless steel moulding bay similar machine and floor moulding facilities are provided. There are four furnace units, one of which is a " Metalectric " arc furnace capable of melting 1½ tons of metal every 90 minutes, and equipped with oxygen blowing apparatus used for the control of the metal carbon content. The three high-frequency furnaces of 10 cwt,



A.P.V. Factory at Crawley



The Press Shop

5 cwt and 2 cwt capacity respectively, each have two furnace body units fed by the same power equipment. The maintenance of two bodies enables one to be released for relining without affecting production. In this foundry stainless steel castings of 2 tons maximum finished weight can be produced.

Each of the two foundry bays is served throughout its length by overhead travelling cranes, and in addition to numerous pillar cranes adjacent to the machines, central jib cranes of 5 cwt to 15 cwt capacity are set at strategic points in the main floor area.

A well-equipped physical and chemical laboratory is constantly employed on routine analyses and tests designed to check all the work passing out of the foundry. There is also a 300kV X-ray plant with a capacity of 3in, which is capable of handling castings in stainless steel, aluminium and gunmetal. Supplementing this equipment is a Gamma-ray radioactive isotope apparatus.

A particularly noticeable point about this foundry is the excellent working conditions. Both ventilation and lighting are of a high standard throughout, whilst fatigue is reduced to a minimum by the installation of adequate lifting equipment serving all parts of the floor. In the employees amenities section well arranged cloak-rooms are fitted with heated clothes racks, whilst in the wash-houses several shower-baths are provided.

It is of some interest to note that of the 1400 people involved in this works transfer to Crawley the majority of those affected have agreed to move with the firm and the loss of skilled personnel has been insignificant.

Aluminium and Copper-base Alloy Foundry

A Spring Works Expansion.—As part of a development plan involving the reorganisation of production now concentrated in a multi-storey building which does not lend itself to modern flow-line methods, George Salter and Co., Ltd., recently acquired a new site in Smethwick for extensions to its spring factory in High Street, West Bromwich. The new site in Spon Lane, Smethwick, is about 2 miles from the parent factory, and existing buildings with a floor space of 26,400 square feet are to be extended to add another 9000 square feet. Some departments of the original factory will be moved to the Smethwick premises and production will be reorganised on modern lines.

An Experimental Air-Cooled Turbine*

No. III—*(Concluded from page 716, May 15)*

RESEARCH ON INTERNALLY AIR-COOLED TURBINE BLADES

By D. G. AINLEY, B.Sc.†

The previous abstracts of this paper were concerned with the design of the turbine rig and the manufacture of the blades. The following abstracts are taken from the second part of the paper, in which the author describes a comprehensive series of tests which were made on the turbine to determine the cooling characteristics and the overall stage performance of the air-cooled blading. These blades had, internally, a multiplicity of passages of small diameter along which cool air was passed through the whole length of the blade.

The Test Rig

A description of the experimental turbine and the cooled blades with which it was fitted has been given in Part I and it only remains to describe briefly the rig as a whole and its associated instrumentation.

The driving air, supplied from an electrically motored centrifugal compressor, was fed via a large pre-entry chamber into a group of eight combustion chambers immediately upstream of the turbine (Fig. 1 *ante*). The hot products of combustion then passed through the turbine stage and were exhausted through eight short exhaust pipes grouped round the turbine outlet into an exhaust collector box. From this exhaust box the gas was finally discharged through a single exhaust duct to atmosphere.

The cooling air delivered to the rig was divided into a number of independent feeds supplying individual regions inside the turbine, each feed being separately controlled and metered.

This arrangement presented a complex external appearance to the rig, but it had the over-riding advantage that the cooling air to any individual region of the turbine could be altered without causing simultaneous alterations to the remaining cooling flows.

The Combustion System.—The high inlet gas temperatures envisaged necessitated the development of a combustion system especially suited to the rig. The major requirements were (1) stable operation over a wide air-flow range, an outlet temperature range of 600–1200 deg. Cent. (1100–2200 deg. Fah.), and a pressure range of 1–3 atm. ; (2) reasonable combustion efficiency ; (3) ignition at low air-flow and outlet temperature, and (4) there was to be no danger of burning out the sheet metal chamber lining, since this might have seriously endangered the blading. The combustion chamber finally evolved by the Combustion Department of the National Gas Turbine Establishment is shown in Fig. 10. The outlet end of the combustion chamber lining was film-cooled by injecting cool air at low velocity through a large number of perforations uniformly distributed over the liner. This system was quite successful in maintaining the liner and outer wall of the chamber at a safe temperature but at the same time it created a thick film of cool air near the walls which resulted in a relatively poor gas-temperature distribution at the inlet to the turbine. The peak temperatures exceeded the mean temperature by an amount approximately equal to 20–25 per cent of the mean gas temperature rise in the chambers.

Cooling Characteristics of the Rotor Blades

(*a*) *Characteristics at Zero Mean Incidence and* Re_g‡$=1\times10^5$.—The measured variation of rotor-blade temperature along the blade span, both without cooling and with a cooling flow ratio of 0·02, is illustrated in Fig. 11. Also shown is the corresponding spanwise variation of gas temperature, the temperature at any spanwise position being the mean value of (stagnation temperature measured relative to the moving row) at that radius around the annulus. During the tests on the cooled blades only the mean gas temperatures could be directly measured and the radial distribution of gas temperature was derived from previous traverses of the gas flow,

* The Institution of Mechanical Engineers, May 1st. Abstract.
† National Gas Turbine Establishment.
‡ See Notation overleaf.

made in the plane of the rotor disc, with all blading removed.

The spanwise variation of blade temperature was clearly influenced by the gas temperature distribution and non-uniform cooling along the blade chord is apparent. The peak gas temperature occurred near the mid-span of the blade and the greatest variation of metal temperature along the blade chord also occurred in this vicinity. With no cooling, the blade temperatures approximated to the local effective gas temperatures, the blade temperatures being slightly less than the gas temperature towards the blade root, owing to heat abstraction from the blade root by the disc cooling-air, and slightly greater than the gas temperature near the blade tips owing to heat conduction along the blade span from the hot mid-span region towards the cooler tips where the gas temperatures were relatively low.

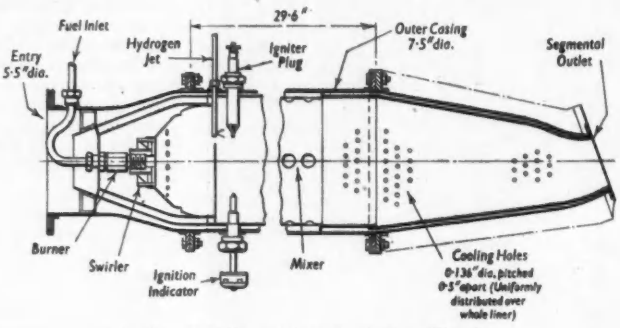
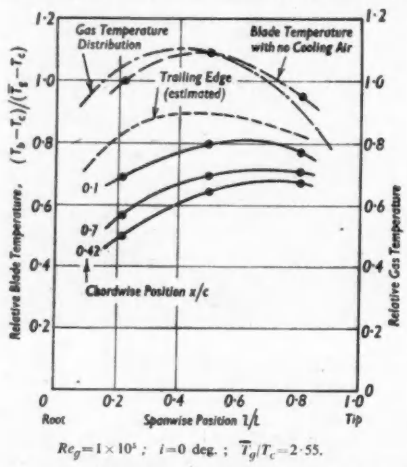


Fig. 10—High-Temperature Combustion Chamber

The measured variation of blade temperature along the blade chord at mid-span is plotted in Fig. 12 for two values of cooling-flow ratio. The mean level of blade temperature fell as the cooling flow ratio was increased and, at the same time, the difference in temperature between selected points along the blade chord increased. The chordwise distribution in temperature could be approximately defined for a wide range of cooling-flow ratio by a single curve relating the parameter $(T_b - T_{bM})/(T_g^* - T_{bM})$ with chordwise position, x/c, where T_{bM} is the mean blade-temperature along the section considered. In Fig. 12 the blade relative temperature has been based on the local gas temperature at the section considered, T_g^*, rather than the overall mean gas temperature $\overline{T}_g$. This modified definition has been adopted since, with the low thermal conductivity of the blade material, the blade temperatures along the chordwise section at mid-span will be influenced to a greater extent by the local gas temperature at that section than by the mean gas temperature over the whole span.

No direct measurements of blade temperature at the leading and trailing-edges were made. This was deliberate, to avoid weakening the blades mechanically. It was possible, however, to estimate these temperatures reasonably closely by comparing the chordwise temperature distribution shown in Fig. 12 with the temperature distribution which was extensively measured on a nearly identical blade in a cascade tunnel (Smith and Pearson, 1950) at a similar value of gas flow Reynolds number and cooling-flow ratio. This comparison, together with a comparison of the turbine and cascade blade sections, is shown in Fig. 13. Compared with the cascade blade, the turbine blade exhibited a slightly higher temperature in the leading half of the blade section and a slightly lower temperature in the trailing half of the section, partly owing to the turbine blade having a slightly larger number of cooling passages in the trailing half of the blade section than the cascade. Also, as will be demonstrated later, there is reason to believe that the turbine blade operated with a larger proportion of the boundary layer in a turbulent state than the cascade, and this might be expected to modify slightly the chordwise temperature distribution. By use of the cascade results as a guide, a reasonable extrapolation of the turbine blade temperature measurements to the trailing-edges could be made, as shown by the broken lines in Figs. 12 and 13.



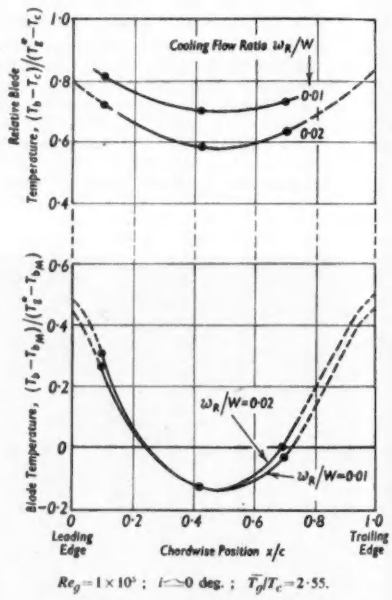
$Re_g = 1 \times 10^5$; $i = 0$ deg. ; $\overline{T}_g/T_c = 2{\cdot}55$.

Fig. 11—Variation of Blade Temperature Along Rotor-Blade Span when Cooling-flow Ratio = 0·02

The blade temperature falls rapidly with increasing cooling-flow ratio, when the latter is small, but at high cooling-flow ratios (>0·02) the rate of decrease falls off. When the losses in engine performance associated with the air quantities required for cooling are borne in mind, the optimum cooling-flow ratio for this blade probably lies in the range 0·01–0·02.

(b) Influence of Gas Flow Reynolds Number.—The variation of the mass average rotor-blade temperature with gas flow Reynolds number for a constant cooling-flow ratio (0·02), and zero mean incidence, is illustrated in Fig. 14. Also shown is the corresponding relation that was determined for the cascade blade (a small correction to the cascade tests as reported by Smith and Pearson (1950) being necessary to allow for the fact that the cascade blade had no root fixing attached). Appreciable differences in cooling between turbine and cascade blades are evident. The amount of cooling obtained on the turbine blade was less than that on the cascade blade and, furthermore, the turbine blade did not show an appreciable reduction in temperature with increasing Reynolds number.

The discrepancy between turbine and cascade blades has been studied further by comparison of the respective relations between the mean values (for the whole blade) of gas flow Nusselt number and Reynolds number (Fig. 15). These relations are only approximate, and were estimated from a knowledge of the blade temperature, gas temperature, cooling air mass flow, and cooling air inlet temperature combined with data published by Humble, Lowdermilk, and Desmon (1951) for heat transfer in passages of circular cross section and large length/diameter ratio. An approximate correction was made for the heat passed to the blade root platform, disc rim, and disc cooling air : *Nu* and *Re** have been defined* in accordance with recommendations made by Andrews and Bradley (1948). Also, for comparison, the calculated relations of *Nu* and *Re** have been added for two-dimensional flow and various assumed points of transition on a blade very similar to the tested blades. This comparison suggests that the turbine blade operated with a much greater proportion of the boundary layer in a turbulent state than the cascade blade. This seems plausible since the inlet gas flow to the turbine stage would be very much more irregular and turbulent than the flow into the cascade tunnel and, moreover, there is a considerable variation in gas flow incidence along the span of the untwisted turbine blade.



$Re_g = 1 \times 10^5$; $i \simeq 0$ deg. ; $\overline{T}_g/T_c = 2{\cdot}55$.

Fig. 12—Chordwise Temperature Distribution in Mid-Span Section of Rotor Blade

Nevertheless, there is a clear inference that heat transfer coefficients derived from cascade tests are not necessarily a reliable guide to heat transfer on similar blades in a turbine stage. The differences are probably associated with differences in mainstream turbulence and secondary flows, and future investigations into the role played by these factors on the heat transfer coefficients may prove of value if the

* See notation.

Notation

C_{pc}—Specific heat of cooling air at constant pressure, B.Th.U. per lb per deg. Fah.
C_{pg}—Specific heat of gas flow at constant pressure, B.Th.U. per lb per deg. Fah.
c—Blade chord
g—Gravitational acceleration, feet per second per second.
i—Mean incidence of gas flow on to rotor blade.
J—Mechanical equivalent of heat, ft-lb per B.Th.U.
L—Blade height
l—Distance along blade span measured from blade root.
M—Mach number.
Nu—Nusselt number based on blade chord and gas thermal-conductivity at blade temperature.
Note.—Nusselt number is defined as : heat-transfer coefficient × blade chord / gas thermal-conductivity
$\overline{Nu}$—Mean Nusselt number for blade.
P_i—Mean total pressure of gas stream upstream of the nozzle row.
P_o—Mean total pressure of gas stream downstream of the rotor row.
Pr—Prandtl number.
Re_c—Reynolds number of cooling air-flow based on passage diameter, mean cooling-air velocity, and density and viscosity at bulk temperature of cooling air.
Re_g—Reynolds number of gas flow based on blade chord, gas outlet velocity from blade (measured relative to the blade), and density and viscosity at outlet from blade.
Re^*—Reynolds number of gas flow based on blade chord, gas outlet-velocity from blade, and density and viscosity corresponding to average of blade and gas temperatures.
T_b—Blade temperature.
T_{bM}—Mean of blade temperatures measured along a blade chord (area mean value).
$\overline{T}_{bM}$—Mass average temperature of entire blade (excluding root).
T_c—Cooling-air inlet temperature.
T_g—Total temperature of gas stream measured relative to the row of blades considered.
T_{gs}—Static temperature of gas stream.
$\overline{T}_g$—Mean total gas temperature over whole annulus.
T_g^*—Circumferential mean of total gas temperature at a constant radius.
T_i'—Mean gas temperature at exit from combustion chambers.
T_i—Mean gas temperature immediately downstream of nozzle row.
ΔT_w—Temperature drop in main gas stream equivalent to work done by the turbine stage.
U_m—Mean rotor-blade speed.
U_t—Tip rotor-blade speed.
W—Gas mass flow at exit from combustion chambers.
w_1, w_b, w_b—Cooling-air mass flows to annulus walls (see main text).
w_N—Cooling-air mass flow to the nozzle blade row.
w_R—Cooling-air mass flow to the rotor blade row.
x—Distance measured along blade chord from leading-edge.
x'—Distance measured along blade surface from leading-edge.
γ—Ratio of specific heats.
η—Aerodynamic efficiency of stage (definition given in text).

design of cooled blades is eventually to be placed on to a sound basis.

Although it is seen that the gas flow Reynolds number has little effect on the average degree of cooling in the present rotor blades, it might be expected to influence the temperature gradients in the metal. This will arise since the amount of heat transmitted through the blade from the gas flow to the cooling air increases with Reynolds number, whilst the thermal conductivity of the metal remains constant. The measured effect of Reynolds number on the chordwise

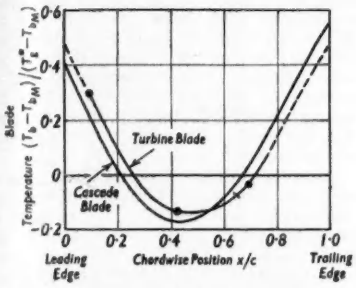


Fig. 13—Comparison of Chordwise Temperature Distribution of Turbine and Cascade Blades

temperature distribution at mid-span is shown in Fig. 16. The mid-chord temperatures decreased with increasing Reynolds number while the temperatures towards the leading and trailing edges remained substantially unchanged. This effect may be important owing to its repercussion on the thermal stresses in the blade.

(*c*) *Influence of Gas Flow Incidence.*—The blade temperatures were substantially unaffected by the gas flow incidence over a range of −10 deg. to +8 deg. ($5{\cdot}4 > 2gJC_{pg}\Delta T_w/U_m^2 > 2{\cdot}6$) and commenced to rise slowly at incidences less than −10 deg. Qualitatively, this agrees with cascade tests (Bammert and Hahnemann, 1946). Quantitatively, however, the effect is seen to be small over a wide range of turbine stage loading.

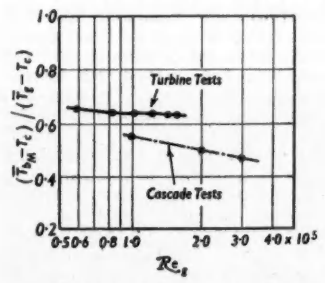
Thermal Stresses

(*a*) *Stresses Under Steady Operating Conditions.*—With the cooling characteristics of the rotor blades explored over a wide range of operating conditions, it becomes possible to study the thermal stresses, and their repercussion on blade life, which may arise from the non-uniformity in cooling.

The direct thermal stresses over the mid-span section of the present rotor blade (where temperature gradients are nearly a maximum) have been calculated for an instance in which the

Effective mean gas temperature relative to the rotor blade	= 1,000 deg. Cent. (1,832 deg. Fah.)
Cooling-air inlet temperature	= 200 deg. Cent. (392 deg. Fah.)
Cooling-flow ratio	= 0·02
Mean gas incidence	= 0 deg.
Mean Re_g	= 1×10^5
Young's modulus	= 20×10^6 lb per square inch
Coefficient of expansion	= 18×10^{-6} in per inch per deg. Cent.

The calculations assume perfect elasticity in the blade material, freedom of the blade to



$w_R/W = 0{\cdot}02$; $i = 0$ deg. ; $\bar{T}_g/T_c = 2{\cdot}50$.

Fig. 14—Variation of Average Rotor-Blade Temperature with Gas Flow Reynolds Number

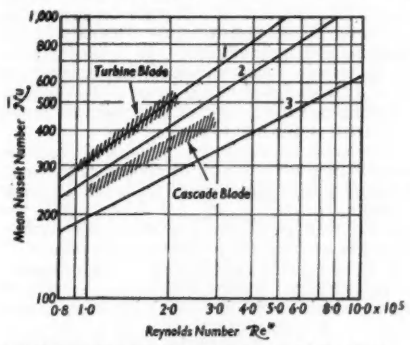
expand, freedom of the blade to bend, and absence of "end effects" due to constraints at the ends of the blade span.

The resulting direct thermal stresses and the temperature distribution across the blade section are shown in Fig. 17. These thermal stresses are seen to be large, being compressive in the vicinity of the hot leading and trailing edges and tensile in the cooler central portion of the blade. The compressive stresses at the hot leading and trailing edges are so great that a local compressive creep strain may be expected to occur rapidly in these regions, leading to a partial relaxation of the thermal stresses. Relaxation in the compressive stress at the leading and trailing edges will, of course, also lead to some relaxation of the tensile stress at the mid-chord section.

Centrifugal and gas bending stresses must be added to the thermal stresses, and will reduce the magnitude of the compressive stresses at the leading and trailing edges and increase the tensile stresses at the mid-chord region. In practice it may be expected that creep strain in the vicinity of the leading and trailing edges will proceed fairly rapidly until the combined stresses in these regions approach zero. General creep over the whole blade section will then occur slowly, the actual rate being dictated largely by the local creep rate in the cool, but highly stressed, mid-chord region.

It is interesting, therefore, that the net effect of the thermal stress is to transfer the major working stresses in the blade to the coolest (and hence strongest) portion of the blade section.

With the spanwise distribution of gas temperature measured in the present installation, it has been deduced that the weakest locality (in terms of prolonged creep) in the blade occurs at the mid-chord region of a blade section lying approximately 0·4× blade height from the root. From the creep properties of the sintered blade



(1) Calculated assuming transition at $x/c = 0{\cdot}5$ on the convex surface and at $x/c = 0{\cdot}1$ on the concave surface.
(2) Calculated assuming transition at $x/c = 0{\cdot}5$ on upper surface only.
(3) Calculated assuming completely laminar flow.

Fig. 15—Comparison of Turbine and Cascade Blade Heat-Transfer Coefficients with Calculated Values

material it is estimated that, at full turbine speed (9000 r.p.m.), and with a mean inlet gas temperature of 1100 deg. Cent. (2012 deg. Fah.) a cooling air temperature of 200 deg. Cent. (392 deg. Fah.), and a cooling flow ratio of 0·02, the present blades might have a life expectation in the region of 500–1000 hours. On the same basis, it is estimated that with an uncooled blade of the same material having the same life, the maximum permissible mean inlet gas temperature would be approximately 830 deg. Cent. (1526 deg. Fah.).

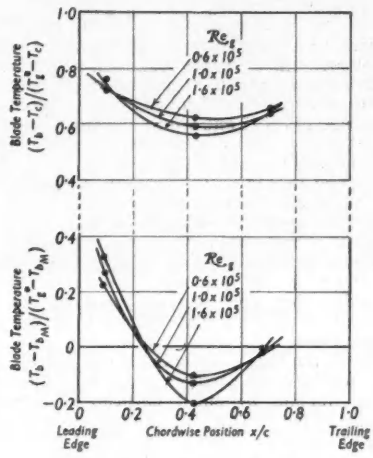
Thus the cooling system, with a cooling flow ratio of 0·02, might be expected to permit an increase in gas temperature of roughly 270 deg. Cent. (486 deg. Fah.).

It should be borne in mind that if the inlet mean gas temperature to the present turbine were 1100 deg. Cent. (2012 deg. Fah.) the circumferential mean value of gas temperature in the centre of the annulus would be nearly 1200 deg. Cent. (2192 deg. Fah.). The life quoted above is influenced by the radial position and magnitude of this peak temperature. If the inlet gas temperature distribution were uniform, for the same endurance the gas temperature might be raised by a further 40 deg. Cent. (70 deg. Fah.), approximately.

Since the high stresses occur in the cooler portions of the blades it might be anticipated that loss of metal on the hottest surfaces due to oxidation will only become critical when so much is lost that some of the cooling passages become exposed to the hot gas stream.

The effects of blade vibration, assuming that vibration in the first fundamental mode can be avoided, remain as unpredictable as with uncooled blades, although cooled blades will necessarily have relatively thick blade sections and possibly fairly thick trailing edges, which might tend to diminish vibration troubles.

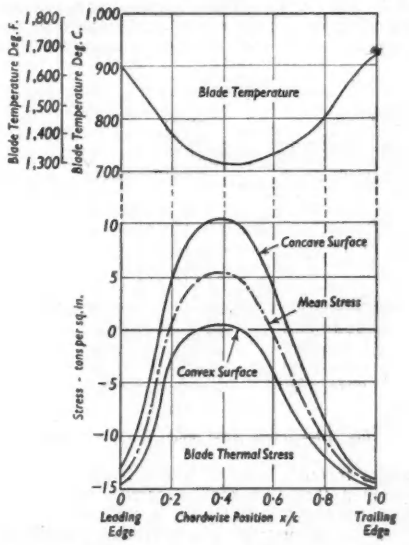
(*b*) *Stresses Due to Thermal Shock.*—The maximum tensile stress in the trailing edge would occur at the instant when the difference between the mean blade temperature and the



$w_R/W = 0{\cdot}02$; $i = 0$ deg. ; $\bar{T}_g/T_c = 2{\cdot}50$.

Fig. 16—Effect of Gas Flow Reynolds Number on Chordwise Temperature Distribution at Mid-Span of Rotor Blade

trailing edge temperature becomes a maximum. It is fortunate that at this instant the trailing edge temperature will have attained a value approaching the cooling air temperature and the material strength will then be relatively high. Even so, approximate calculations indicate that the magnitude of the maximum tensile stresses will be of the same order of magnitude as the rupture strength of the material, so that severe shock cooling resulting from a sudden "blow out"



$\bar{T}_g = 1000$ deg. Cent. (1832 deg. Fah.) ; $T_c = 200$ deg. Cent. (392 deg. Fah.) ; $Re_g = 1 \times 10^5$; $w_R/W = 0{\cdot}02$; $i = 0$ deg. ; $E = 20 \times 10^6$ lb per square inch ; thermal expansion $= 18 \times 10^{-6}$ in per inch per deg. Cent. (10^{-6} in per inch per deg. Fah.).

Fig. 17—Calculated Thermal Stresses in Mid-Span Section of Rotor Blade

in the combustion chambers may constitute a serious danger to the blades.

It is worthy of note that the shock cooling stresses are not governed to an important degree by the non-uniformity in cooling occurring under normal operating conditions. If the internal cooling in the vicinity of the leading and trailing edges were increased to such an extent that the

cooling were uniform along the blade chord the shock cooling stresses would still remain at about the same magnitude.

Cooling Air Pressure Losses

In a cooled gas turbine engine the pressure losses in the cooling system are important to the extent that the blades should be capable of passing the design quantity of cooling air with a cooling air inlet pressure not exceeding the maximum air pressure occurring in the engine cycle. In the present instance it was found that when the turbine was operated at full speed with a ratio of inlet gas temperature to cooling air temperature of 2·5, and a gas flow Reynolds number (related to the rotor blades) of 1×10^5, a nozzle cooling flow ratio of 0·022 and a rotor cooling flow ratio of 0·018 could be passed when the inlet cooling air pressure was equal to the main gas stream inlet total pressure. Within normal limitations to cooling air pressures in a gas turbine engine, therefore, the present blades will pass an ample quantity of cooling air.

It was found that the magnitude of the radial tip clearance had little effect on pressure loss, provided that the clearance exceeded about 0·020in on the rotor blades and 0·030in on the nozzle blades.

Before the tests commenced it was feared that the small cooling passages might be subject to severe fouling by small particles of foreign matter in the cooling air. Simple cloth filters, comprising three layers of aircraft fabric, were installed in the cooling air ducts leading to the blades. With this elementary precaution it was found that over a period of 120 hours of testing no measurable fouling occurred in the blade cooling passages. The cooling air passed into the filter was free from oil, but the solid particle content (atmospheric pollution combined with rust and scale from the air ducts) was sufficiently large to cause almost complete blockage of the filters in fifty hours.

Effect of Cooling on the Stage Aerodynamic Efficiency

Estimation of the effect of cooling on the thermal efficiency of a gas turbine engine has formed the subject of published papers of a theoretical nature by Brown (for example, Brown, 1950 and 1951). These papers study chiefly the effect on overall engine performance of the heat loss from the main gas stream when it

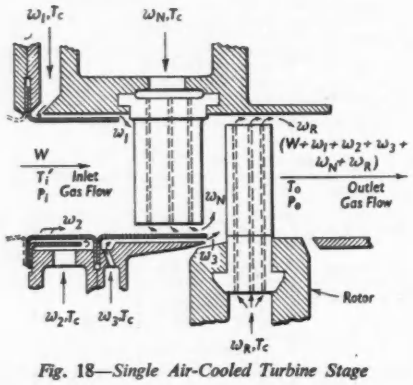


Fig. 18—Single Air-Cooled Turbine Stage

passes through rows of cooled blades, it being assumed that this heat is carried right away from the engine with the blade coolant.

Air cooling presents a rather different problem, since the coolant, when it has performed its task of cooling a row of blades, or a wall, is mixed into the main gas stream and provides an additional measure of energy that can be extracted in the form of useful work in following stages.

A single air-cooled turbine stage of the type tested is shown in Fig. 18. A gas flow W enters the turbine stage at an inlet total temperature T_i', and total pressure P_i. A cooling flow w_N, passes down the nozzle blades and mixes into the gas stream in the axial space between the nozzle and rotor row. Additional cooling flows w_1, w_2 and w_3 are used to cool the annulus walls and are also mixed into the gas stream at various points upstream of the rotor row. It is assumed that all the heat lost from the gas stream to the cooled surfaces is absorbed by the cooling air, hence the mean total gas temperature just downstream of the nozzle row, T_i, is given by :

$$T_i=[WT_i'+(w_N+w_1+w_2+w_3)(C_{pc}/C_{pg})T_c]/[W+w_N+w_1+w_2+w_3]$$

Thus, a gas mass flow of $(W+w_N+w_1+w_2+w_3)$ at an inlet total temperature T_i passes through the rotor row and does useful work. The temperature drop in the gas stream, ΔT_w, resulting solely from the work done on the rotor blades, is given by :

$$\Delta T_w=\text{blade horse-power}\times550/(W+w_N+w_1+w_2+w_3)C_{pg}J$$

The adiabatic temperature drop is assumed to be given by

$$\Delta T_{ad}=T_i[1-(P_o/P_i)^{\gamma-1}/\gamma]$$

and the stage aerodynamic efficiency by :

$$\eta=\Delta T_w/\Delta T_{ad}$$

When mechanical and disc windage losses are neglected, blade horsepower=shaft horsepower +pumping horsepower, where the "pumping horsepower" is the power required to discharge the rotor blade cooling air, w_R, at the blade tips with a peripheral component of velocity equal to the tip speed, U_t (that is, pumping horsepower $=w_RU_t^2/550g$). Finally, the total gas temperature downstream of the rotor (after mixing of the rotor blade cooling air) is given by :

$$T_o=\{(W+w_N+w_1+w_2+w_3)(T_i-\Delta T_w)C_{pg}+w_R(T_cC_{pc}+U_t^2/J\,.\,g)\}/(W+w_N+w_R+w_1+w_2+w_3)C_{pg}$$

If injection of the cooling air into the main gas stream resulted only in a reduction in mean gas temperature (a reduction which can be readily calculated), and had no influence on the nozzle and rotor blade pressure loss coefficients, the stage aerodynamic efficiency, as defined above, would remain independent of the quantity of cooling air used and would be equal to the total head efficiency of a geometrically similar uncooled stage (that is, having no cooling air).

In practice it might be anticipated that the aerodynamic efficiency of the cooled stage would be slightly less than that of an uncooled stage owing to mixing losses and flow interference losses caused in the regions where the cooling flows are discharged into the main gas stream.

In the following brief discussion the reduction in the stage aerodynamic efficiency, as defined above, which results from such losses as termed "cooling flow losses."

These cooling flow losses are quite distinct from any reduction in effective expansion work per unit gas mass flow resulting from dilution of the gas stream by the cooling air. The latter reductions in work output do not represent a "loss" in the present meaning of the word, but merely a readily calculable difference in performance from a simple uncooled turbine doing the same duty. The cooling flow losses as defined here, however, are not calculable and must be sought by experiment.

A number of tests were made on the experimental turbine to evaluate these losses as far as circumstances would allow. It was found that when the turbine was tested with a hot gas stream the losses in efficiency due to injection of various proportions of cooling air were masked by changes in efficiency resulting from simultaneous alterations in nozzle and rotor blade tip clearance, caused by changes in thermal expansions of different portions of the turbine structure.

For this reason a number of tests were made with cold air (the "cooling" air then being at the same temperature as the main stream) to investigate independently the effects of (1) the combined liner cooling air quantity $(w_1+w_2+w_3)$, (2) the nozzle cooling air, w_N, and (3) the rotor cooling air, w_R. Space permits a summary only of the results to be given.

The combined inlet liner flow $(w_1+w_2+w_3)$ caused a reduction in efficiency roughly proportional to the cooling air quantity. When the combined cooling air quantity amounted to 3 per cent of the mainstream flow, W, the reduction in stage aerodynamic efficiency, was approximately 1 to 2 per cent. The flow w_3 constituted roughly half the total quantity $(w_1+w_2+w_3)$ and it is believed that the reduction in stage efficiency was largely due to disturbance of the gas flow in the vicinity of the rotor blade root caused by injection of this flow, w_3, without swirl immediately upstream of this region.

It was found that both the nozzle and rotor cooling flows had very little effect on stage efficiency. By averaging a large number of tests it was concluded that the combined effect of nozzle and rotor cooling air quantities was to reduce stage efficiency by less than 0·5 per cent when the cooling flow ratio in each row was 0·02.

The peak aerodynamic efficiency of the turbine stage, without cooling air, and at a Reynolds number (rotor blade) of $1\cdot6\times10^5$ was about 79 per cent. This low efficiency was primarily attributable to the large radial tip clearances on the rotor and nozzle rows, and to the high design blade loading. Calculations indicate that the nozzle tip clearance was particularly deleterious to efficiency, an increase of roughly 5 per cent in stage efficiency being predicted if the tip clearance was eliminated entirely. This fact alone, apart from the cooling difficulties described in an earlier section, emphasises the desirability of fully shrouded nozzle blades.

The absolute efficiency of the stage was of minor importance to the cooling investigations and no attempt was made in the design of the experimental turbine and blades to achieve high stage efficiency. The cooling flow losses, however, are found to be quite small and by careful design they can probably be made even smaller.

Conclusions

Internally air-cooled blades of the type described will apparently permit an increase in gas temperature of about 270 deg. Cent. (486 deg. Fah.) above the permissible value for an uncooled blade of the same material when a cooling flow ratio of 0·02 is used. At the time of writing a few hours only of actual running at a high gas temperature has been accomplished, the maximum mean inlet gas temperature attained being about 1000 deg. Cent. (1830 deg. Fah.). In addition, the blading has been subjected to several cycles of severe thermal shock, the gas temperature being reduced instantaneously from about 950 deg. to 120 deg. Cent. (1740 deg. to 250 deg. Fah.). At this juncture the blades remain in a sound condition.

The performance of these blades does not represent a limit to the potentialities of internal air cooling. It merely represents a first exploratory step. The form of the present blades was decided more than six years ago, at a time when the problems of cooling and the problems of manufacture were appreciated to a much smaller extent than at present.

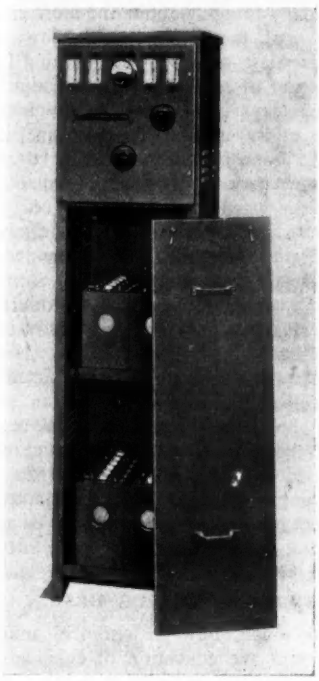
Nevertheless, the results relating to both the cooling characteristics of the blades and the aerodynamic losses created by the cooling system clearly demonstrate the practical feasibility of air cooling in gas turbine engines. Much further development lies ahead. This must be directed both at increasing the degree of cooling in blades and in devising alternative and cheaper methods of manufacture. The ultimate forms and capabilities of air-cooled blades are yet uncertain, but the advances made up to the present are undoubtedly encouraging.

Search for Columbite

Prospecting for columbite proceeds all over South Africa owing to the heavy demand for this metal. So far no deposits on any considerable scale have been proved, but several very promising occurrences are in process of being opened up. One or two of these are in the Low Country of the Transvaal, on the Letaba River, also near Mica, and a Johannesburg company is prospecting a deposit in Southern Rhodesia from which samples have given about 55 per cent columbite and 10 per cent tantalum. A Netherlands company is said to have taken over adjoining ground. That there should be anxiety to find payable columbite propositions is understandable in view of the huge price which the mineral is fetching. The United Tin Areas of Nigeria has been receiving £2500 per ton for its columbite output for the last six months. Another Nigerian company, Gold and Base Metal Mines of Nigeria, has also been cashing in heavily on the mineral. Output in 1952 was 570 tons tin and 26 tons columbite, and this year it expects to produce 670 tons tin and 80 tons columbite. Most of the columbite supply of the world comes from Nigeria, and the biggest market is the United States.

Emergency Lighting Sets for Smaller Buildings

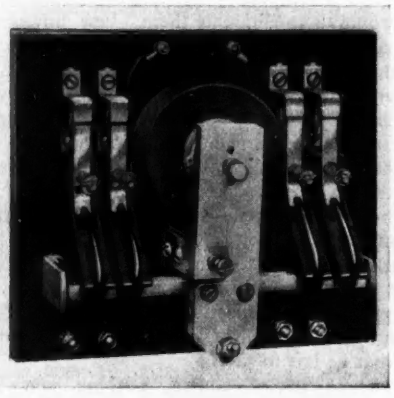
A NEW range of self-contained automatic emergency lighting equipments for small works, hospitals, schools and similar buildings is being made by Nife Batteries, Ltd., Redditch, Worcester. These sets, known as the "Nife-Neverfayle Minor" series, are available either for maintained or for non-maintained systems.



Emergency Lighting Set with Front Cover Removed

In the maintained system the emergency lamps form part of the normal lighting and are switched over automatically immediately a mains failure occurs. In the non-maintained system the emergency circuit is energised only when the mains supply is off.

As shown in our first illustration, the lighting sets are housed in sheet steel cubicles in which the middle and lower compartments house 15V, 25V or 50V batteries, while the control gear and instruments are accommodated in the upper compartment. The batteries are made up of "Nife" nickel cadmium alkaline cells. The control gear and charging equipment in the upper compartment consists of a double-wound vacuum impregnated transformer, a full-wave bridge-connected selenium rectifier, a contactor, a manually operated charge rate control, moving-coil instruments and a master rotary switch. A test circuit consisting of an ammeter, a resistance and a retractive switch, is included so that the state of the charge can be determined at any time.



Spring-Controlled Contactor for Emergency Lighting Set

The contactor, which is illustrated herewith, is spring controlled and is designed to operate satisfactorily when the supply voltage is below normal. The coil of the contactor operates in conjunction with an economy resistance fed by direct current from a full-wave bridge-connected selenium rectifier. An auxiliary relay is fitted for switching the economy resistance in and out. This relay is set so that it will not close until the mains voltage is higher than that required for positive closure of the contactor and it protects the contactor coil from the danger of a burn-out.

Normally the contactor is arranged to work with metal filament lamps but it can, if required, be made to operate in conjunction with fluorescent tubes. The master switch has four positions —"off," "standby," "charge and standby" and "charge only." For normal operation use is made of the second position. After an emergency operation the master switch is rotated to the second or third positions, depending upon the need or otherwise of providing an emergency supply in the event of mains interruption during quick charging.

The rectifier output is designed to recharge a completely discharged battery in fourteen hours. As there are no losses from the alkaline battery, no trickle-charge circuit is provided.

Die Inspection Tool

THE wire-drawing section of the British Iron and Steel Research Association has for some years been concerned with the development of instruments to measure and inspect the internal taper of dies. An instrument first evolved and known as the "Profilometer" depended on a mechanical three-dimensional trace of the profile. This instrument was a highly accurate research tool and was therefore unnecessarily

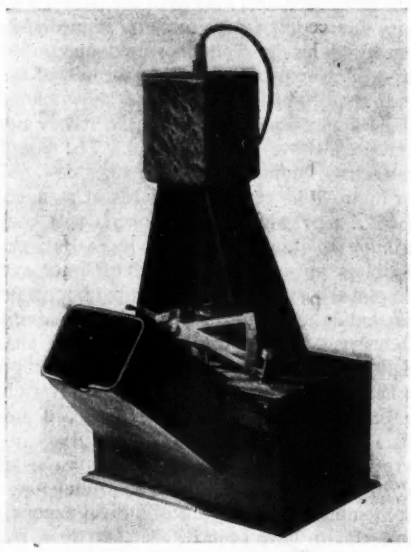


Fig. 1—The "Profiloscope"

elaborate for use in the die shop, where a more simple though less accurate estimate of the profile was desirable. Optical methods suggested the most fitting manner of examining, scoring and ringing marks on a highly polished profile, and an instrument employing a lens system was developed in Germany. This instrument again was of the nature of a research tool and because of its lens system had to be very exactly aligned. The "Profiloscope" which we saw demonstrated last week depends likewise on an optical principle but has no lens system. It is consequently a cheap instrument, needs no alignment and is simple to use; is accurate to $\pm 0{\cdot}5$ deg. and provides good optical patterns of die wear.

The instrument (Fig. 1) employs a narrowly divergent beam passing through the die, which is placed on a tilting table above a screen. When the die is horizontal a small bright circle of light is seen, outside which is a dark band, outside which again is a narrow band of light, all these

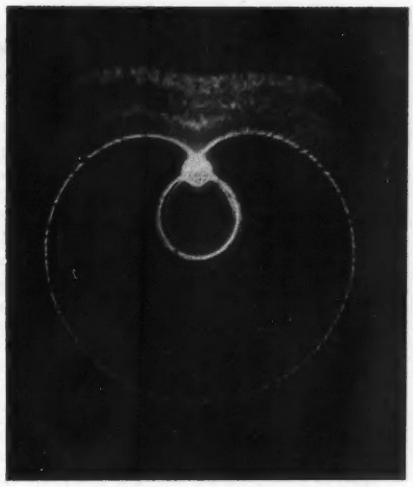


Fig. 2—Image with Die in Measuring Position

being concentric one with another. The innermost circle is due to direct illumination through the die hole and the outer to internal reflection from the tapered region of the die. Should there be any changes in taper, they will immediately become evident as more concentric light circles, one for each change in taper, while a gradual change in taper causes a wider band of light. Any scoring will show as light radial lines radiating from the centre circle and the effect may be intensified by tilting the die. Inspection of the die interior is therefore very simple.

The die angle may be measured by tilting the die, whereupon the outermost circle of light distorts to a heart-shaped image (Fig. 2); by insufficient tilting the cusp at the top of the heart may be made to touch the innermost circle. In this position the direct ray through the die and the outermost reflected ray coincide on the screen. By tilting the die in the other direction a similar situation will be seen, but on the other side. The total angle of tilt of the platform 2ε may then be related to the die angle 2α by means of the relation :—

$$2\alpha = 2\varepsilon + \frac{a+d}{l} \text{ (in radians)}$$

where a and l are instrument constants and d is the die diameter. It follows that before α can be found, the die diameter must be known. In practice since a and d are small in comparison with l, no high degree of precision is required in the value of d.

For example, in a given instrument typical values of a and l are $^{9}/_{32}$in and 8in, respectively. Suppose a given die gives a value of 14 deg. for 2ε and d is taken as 0·4in, 2α then becomes 17·5 deg. Had an error been made and the diameter of die been assumed to be 0·5in, 2α would have been 18·2 deg. It follows then that the die diameter need only be known roughly. In practice, of course, d will be known quite accurately as it is equal to the diameter of the drawn wire.

In arriving at the equation quoted above some assumptions have been made. Taking the most unfavourable conditions likely to be met with, however, the maximum error in the measured value of the die angle due to the assumptions made is no more than 10 minutes of arc and this is well within the designed accuracy of the instrument, which is $\pm 0{\cdot}5$ deg.

The "Profiloscope" lends itself also to exceptionally rapid quality control of die profiles. Works trials have indicated that between 5 and 10 per cent machine working time is lost by replacement of worn tungsten carbide dies. In one works investigated this was estimated to cause a loss of output of 1000 to 2000 tons per year, worth some £35,000 to £40,000. Quality control by means of a robust and simple instrument enables wire-drawing works to plan batch replacements economically, reducing this expenditure considerably.

This instrument has been made for B.I.S.R.A. by the Longworth Scientific Instrument Company, Ltd., Oxford.

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COAL

On various occasions in recent months spokesmen of the National Coal Board have intimated that the accounts for 1952 would show a deficit. It has not, therefore, come as a surprise to learn from the annual report, published last week, that, after making provision for interest and income payable to the Minister of Fuel and Power, the Coal Board finished the year with a balance on the wrong side of £8,200,000, a figure which brought the accumulated deficit since vesting day to £14,000,000. Thus, from a purely business point of view, last year was a disappointing one for the Coal Board. Certainly the output of saleable coal continued to increase, but, regrettably, not at so high a rate as in the preceding year, and although the export tonnage was not so great as was at one time hoped, it was bigger than in any year since the war. Despite higher proceeds from the sale of coal, however, the Board was not able to withstand the effect of higher production costs, costs which were incurred mainly by higher wages and lower productivity and by the increased prices of many stores and materials. This meant that it cost 56s. 9d. to produce a ton of coal in 1952 against 49s. 2d. in 1951. Studied from the financial angle alone, the Coal Board's report for 1952 cannot be described as an encouraging one, a fact which, it is certain, no one regrets more than the Board itself.

Judged by factors other than financial, however, the report creates some uneasy feeling about the immediate future of the coal mining industry. Last year the Board was successful in obtaining a notable increase in mining manpower, and particularly in the number of youths entering the industry. Last year's addition of 22,500 to the manpower total represented an increase of 3·2 per cent over 1951, and the number of face-workers increased by 12,000, or 4·2 per cent. Moreover, the average age of mineworkers fell for the first time for many years, and at the end of 1952 was 40·2 years. Nevertheless, the Board has to report that last year "nearly twice as much coal was lost as in 1951 from stoppages of work and go-slow movements," and that although the trend of output was higher in the early months, it was tailing off in the latter part of the year. Output per man year, at 299 tons, was 4 tons less than in 1951, and output per manshift at the face fell from 3·17 tons in 1951 to 3·15 tons last year. These are factors which are disappointing alike to the Coal Board and to the country as a whole, though it must not be overlooked that with the time necessary for training new recruits, immediately beneficial results from increased manpower could not be expected. Since the end of the year the productivity curve has shown some slight improvement, but even so it has not yet risen above the 1951 level. The Board says that it continues to take steps designed to improve its general standards of management, steps which, it is hoped, will contribute to higher productivity. But the problem is not solely one of improved employer-employee relationship, important as that is to a more successful coal mining industry. The report makes it clear that delays in bringing major reconstruction schemes to completion have adversely affected productivity. When the Board prepared its development plan in 1949 an expenditure, spread over fifteen years, of £520 million—at prices then ruling—was contemplated. The peak of annual expenditure was to have been reached last year, but although the amount spent exceeded the 1951 figure, it was not more than 64 per cent of the sum planned. Quite rightly, the Board emphasises that this lag in capital investment is causing loss of coal, and that by now the reconstruction projects ought to be making a greater contribution to production than they are. The delay over the reconstruction plan, however, is not only a matter of money. There is still a shortage of trained mining engineers for planning the layout of pits. It is a shortage which, by training and other schemes, the Board is undoubtedly doing its best to overcome, realising, as it does, that one of its most important tasks is "to accelerate the execution of major schemes of reconstruction."

More rapid progess with these schemes, coupled with better human relations throughout the industry, would certainly go some way towards removing the recurring anxiety about sufficient coal supplies to provide for future industrial, domestic and export requirements. For at present it is difficult to be optimistic about coal supplies in the months ahead. Last year the home demand for coal was lower than in 1951, general industrial consumption being about 2,000,000 tons, or 5 per cent, less. But even though industry is continually bringing about the more efficient use of coal, the real reason for lower consumption last year was a slackening in the production of some sections of industry in this country. The coal requirements of public utility undertakings are increasing, and the hope is that, with more steel and other raw materials becoming available, the downward trend in industrial coal consumption will be reversed. At the moment the margin between coal production and consumption is narrowing, and very soon the second week's holiday which the miners are taking this year may involve a loss of output of anything up to 4,000,000 tons. Nothing could be more disastrous to industry and to the economy of this country than a coal output below that achieved last year. But unless, with existing resources and equipment, more coal can be gained in every remaining working week of 1953, the grim prospect of a fuel crisis next winter cannot be ruled out as impossible.

EDUCATION FOR DESIGN

How much, how wearisomely much, is said about the education of engineers that has been said times without number before, and usually very much better! Yet how little of what is said is really enlightened by a full understanding of the object of education and the means by which people are educated. Professors, as a rule, whom one might suppose should have special qualifications for acquiring informed opinions upon the subject, seem as little enlightened as the rest. For it is hard for ordinary mortals to look beyond the way things are done to-day and to conceive a very appreciably better way in which they could be done to-morrow. All of us, of course, can see the little things that are wrong and need righting, all of us can observe how some new need is growing and adjust a mechanism approximately to meet it. That is, after all, no more than the ordinary course by which evolution is brought about. There are, also, always those who exaggerate the importance of the defects they see and who make revolutionary but usually impractical proposals to eliminate them. Few, however, have the clarity of mind to suggest, moderately, that something is going seriously wrong with the basic but familiar machinery; that evolution has taken a wrong turning and that the mechanism cannot be adjusted in the ordinary way to meet needs unless a new trend is created. Yet that, in effect, is what Professor M'Ewen is suggesting in the hitherto unpublished lecture that we print as an article elsewhere in this issue; and he does it with so much spirit and gusto that we believe even those who may profoundly disagree with him will still enjoy reading what he has to say.

There is, of course, nothing new in somebody offering criticism of engineering education. We ourselves have been doing

it for nearly a century ! Nor is it wholly new for a university professor to offer the criticism. More practically minded engineers often become impatient with professors. But changes in engineering curricula have, after all, seldom if ever been carried through in the teeth of professorial dislike ! Those changes have come, not only because professors have been convinced by outer criticism, but just as much because they have themselves criticised. Nor is what Professor M'Ewen has to say entirely new. It could be argued that it supports what many others, including ourselves, have repeated *ad nauseam*, that the university education of engineers is too narrowly technical; that it leans too much towards the making of researchers, professors and critics; too much towards the stifling of creative instincts under the discouraging weight of ascertained facts and established theories which have to be absorbed; and too little towards fitting the graduate for the give and take of life in industry. It is the clarity with which the points are made by Professor M'Ewen, the confidence with which he lays a finger upon a weakness of present curricula, which, being redressed, might bring about a beneficial change, that is so marked in the article. He even dares to compare the education given to architects with that given to engineers! He finds it in at least one respect, the attention given to design, markedly superior ; and he disposes of the criticism that, for the purpose of assigning merit, it is difficult to judge between differing designs by pointing out that that is just what is done for architectural students. He suggests that it could equally well be done for engineering students were it to become a more general practice for engineering professors to act also, as architectural instructors do, as consultants for design in industry, and thus themselves acquire experience.

In his recent presidential address to the Institution of Mechanical Engineers, Sir David Pye referred to " a small works where you might say that the spirit of design was rampant," but for which the designers were recruited, not from universities, but direct from school. Would they have rampaged, one cannot help asking, if they had experienced the somewhat damping and discouraging discipline of a university curriculum? Yet should not a university course encourage rather than repress in those with creative minds a rampant and raging desire to design ? Surely the product of a university ought to be not inferior in that respect to men originally taken into industry direct from school but, out of fuller knowledge and a more acutely trained mind, greatly superior. It is, of course, true that the number of designers, as such, needed by industry is relatively small. No doubt that is why less attention than there might be is given by universities to the training of designers. But there is more involved here than design alone. It is not only in engineering design that creative minds are needed. They are of inestimable value in other spheres, of production, organisation and administration. What Professor M'Ewen has to say is provocative of much reflection. We commend his article to the attention of engineers in general and more particularly to that of industrialists, professors and educationalists.

Literature

Designing by Photoelasticity. By R. B. Heywood, Ph.D., A.C.G.I., M.I.Mech.E., London : Chapman and Hall, 37, Essex Street, W.C.2. Price 65s.

Since the beginning of the late war there has been a tremendous development in the use of experimental methods of stress analysis in the design of complex parts, and in parallel with this there has been a correspondingly large volume of theoretical and experimental research work into the effects of discontinuities and stress raisers. Photoelastic methods have been considerably used both in research and in development design, and their value has been notably demonstrated in the kind of work carried out by Dr. Heywood and his colleagues at Rolls Royce, Ltd., and at the Royal Aircraft Establishment. The flood of published material in these fields has been so great during the last ten years that even with the aid of abstracting journals, such as *Applied Mechanics Reviews*, it is difficult, if not impossible, to keep abreast of more than a few branches of current knowledge. To judge by Dr. Heywood's list of 826 references, he must have been very conscious of the need for this mass of information to be reduced to order, systematised and made available to the designer, teacher and research worker in usable form, with the apparent contradictions resolved and due weight given to the relative reliability of the results. The present book is a combination of a handbook of photoelastic method with such a review, giving rather over half of its space to the latter. Although a designer is interested in both parts of the book, he will not normally be concerned with carrying out photoelastic experiments himself, and conversely for the research or development engineer. Bearing in mind their different needs, the author might, therefore, have done better to have written two separate books, one on photoelastic technique and application, and the other on stress concentrations, in the determination of which photoelasticity is but one technique amongst many. For the high price of the volume under review may prove a deterrent to some of the many who will wish to read it, since many prospective readers will be directly interested only in one of the two parts.

The scope and style of texts on photoelastic technique vary considerably, ranging from the classic work of Coker and Filon to practical guides for the experimental worker. In Part I, Dr. Heywood has aimed rather at the latter. Starting from a limited exposition of the principles, he gives valuable guidance on the design of polariscopes, the choice of photoelastic materials, the problems of and precautions required in model preparation, and the translation of model data into the corresponding results at full scale. Information is given fairly fully for the older two-dimensional techniques, and to a lesser extent for frozen stress methods for three-dimensional applications ; in the latter case, the inherent limitation to problems which are axially symmetric, or otherwise have known principal axes, might have been more clearly brought out. This part of the book bears the imprint of the author's extensive experience and lively personality; it is stimulating and informative, even though at times Dr. Heywood seems a little sweeping. Not all will agree, for example, that " there is little justification for multiple lenses in polariscopes, except for specialised research work and *exhibitionism* " (page 45), and even if the author is right in his technical judgment, the motives of those who disagree with him are not necessarily so unworthy.

In the second part, Dr. Heywood has really undertaken an Herculean task, and it is not at all surprising that the attempt to reduce to order the chaotic mass of published data on stress concentrations, with only a limited part of which it is possible for any individual to be familiar, is less successful than the first part, which is soundly built on the foundations of personal experience. Part II of the book is, therefore, more controversial and more open to critical discussion. It is not clear, for instance, why the author prefers the results of Jacobson and Weigand to those of Thum and Bautz for shouldered shafts in torsion (page 195), and his criticism of Sonntag's formula (page 196) is less than just. Sonntag's formula is

$$K=1+(d/12R)[1-(1+2R/d)/\{\Delta(1+6R/d)\}],\ \Delta=D/d$$

so that in the limiting case as the ratio of diameters Δ tends to unity, K tends to $1+1/\{3(1+6R/d)\}$ and Dr. Heywood states that " this is obviously an unsatisfactory result, for if the ratio R/d approaches zero, as will happen when an extremely sharp radius is used, then the stress concentration factor should become infinite and not have the finite value of 1·333 as indicated by the formula." But this double limiting procedure is not legitimate. If we return to Sonntag's original formula and take Δ to tend to unity and R/d to tend to zero simultaneously, we obtain $K=1\cdot333+(\Delta-1)/(12R/d)$, which is infinite for R/d zero for all Δ except Δ identically unity, when it becomes indeterminate. This is as it should be, for with Δ unity and R/d zero we have a plain shaft with no notch in it at all and with Δ greater than unity and R/d zero we have a perfectly sudden change in section. Sonntag's formula may be wrong, but surely not for the reasons given by Dr. Heywood, since it emerges successfully from his limit test.

The author's uncritical acceptance of Neuber's theoretical work on notches (page 197 *et seq*), in spite of the large discrepancy between the example calculated by this method (page 201) with that calculated from Frocht's photoelastic results (page 173), is in marked contrast with his very reasonable wish for photoelastic checks to be made of the theoretical results for reinforced holes obtained by Levy *et al* (page 289). Many workers in this field will feel that much more experimental confirmation is required before Neuber's figures can be given unquestioned credence.

Dr. Heywood makes a vigorous attack on the decision of the U.S., U.K., and Canada to adopt the unified thread which he calls " a political manœuvre." By a procedure, the validity of which is open to doubt, involving the use of Neuber's theoretical data, he arrives at a stress concentration factor for the ½in B.S.W. bolt of 5·2, and then dismisses Hetényi's photoelastic result of 2·72 for 1in B.S.W. bolt as wrong. Nevertheless, he concludes that " the optimum size of thread in a bolt of a given diameter depends on a multiplicity of conflicting factors, which on integrating suggest that present sizes, as represented by the Whitworth and B.S.F. standard bolts are a good compromise."

The value of empirical formulæ and laws, within the range of experience circumscribing their validity, is too well known to require argument, and Dr. Heywood has, therefore,

every right to put forward such formulæ in all suitable cases, and particularly when such a formula gives good agreement with the results of mathematical analysis. But it is bad logic to argue thence that a particular empirical formula is, therefore, precise, " in which case is should be possible to derive this formula by mathematical analysis, and because of the simplicity of the solution, one would expect its derivation to be relatively simple, far simpler, in fact, than the complicated mathematical analysis given by Howland." One can but agree with the author's description of this as " a curious thesis."

There is considerable reference in the book to " streamline fillets," and a lengthy discussion of their application. This discontinuous form has been developed by the author empirically to obtain the fillet giving minimum stress concentration in photo-elastic experiments. But it is a little disconcerting to find after all this that an elliptical fillet of axis ratio 4 is " almost identical with the best possible fillet of streamline form " !

One of the most valuable parts of the book is the bibliography. It could have been improved had it been author-indexed.

But if Part II of this book contains material that is open to criticism, there should be borne in mind the remark made earlier in this review about the chaotic mass of material that has needed to be reduced to order. Those who undertake Herculean tasks must be judged on tolerant standards. Dr. Heywood has, indeed, earned the gratitude of workers in this field by undertaking this task ; and if workers in this field, of which the writer of this review is one, express their thanks, curiously, by criticism, the gratitude will be, nevertheless, sincere.

The High-Speed Internal Combustion Engine. By Sir Harry R. Ricardo, LL.D., F.R.S. London : Blackie and Son, Ltd., William IV Street, Charing Cross, W.C.2. Price 40s.

To expound any given subject a writer has the choice of two methods : the epigrammatic and the encyclopædic. If he adopts the epigrammatic, then brevity may lapse into obscurity, a risk recognised even by Horace. In his preface to the fourth edition of *The High-Speed Internal Combustion Engine* Sir Harry Ricardo reveals part of the secret of success with the epigrammatic method :

" Since my first book was published I have given many lectures at various institutions and to students. In these I have found almost invariably that my audiences prefer me to talk of my own experiences, and to air my own views, rather than to go into factual detail."

Many readers of his book will recall, when scanning the above sentence, the memorable words of another researcher—Lord Bacon—who, writing in the seventeenth century, expressed the view that " Studies do give forth directions too much at large, except they be bounded by experience." It is very true, and while we read with attention what Sir Harry Ricardo calls " factual detail " we also read with something akin to conviction when we take note of his experiences. The author does not attempt to explore the early history of the high-speed internal combustion engine. " I am concentrating," he writes, " rather on the research, design and development work which has been carried out in my firm's laboratory during the last thirty-five years, and the experience and lessons I draw from it." Nevertheless, many readers of the book will recall the forward step taken in 1883 by Gottlieb Daimler when he patented his high-speed gas engine. This was found capable of operating at a speed of 900 r.p.m., whereas the maximum speed reached in earlier gas engines was about 180 r.p.m. The chief significance of Daimler's engine lay in the fact that it reduced the weight per horsepower to approximately one-fifth of the weight per horsepower of any earlier four-cycle gas engine. With what astonishment would Daimler have contemplated the position attained by the high-speed internal combustion engine just seventy years after the date of his patent ! Almost at the beginning of this book Sir Harry Ricardo tells us that " We are too fond of crediting a few particular individuals with a monopoly of inventive genius. Ripe seeds of invention everywhere abound, and it awaits only a certain combination of need, of circumstance and, above all perhaps, of chance, to decide which shall germinate." We specially commend to the attention of all readers the passages in which this prescient author gives his impressions as to the future.

Each of the nineteen chapters into which the 416 pages are divided is a short treatise on specific sections of the main subject. All are written with that clarity which has long marked the work of Sir Harry Ricardo. It is astonishing how greatly a clear and simple English style contributes to the pleasure one has in reading a subject of this kind, and it is only to such writings that the description technical *literature* can justly be applied. There is no waste of words, no labouring of the case, no pedantry. A typical illustration is found in the following reference (page 186) to the two-cycle engine : " In its simplest expression, namely, the crankcase compression version, the two-cycle engine has the very minimum number of working parts but also the minimum number of virtues." This is how we might suppose Bunyan would have described such a machine had he been an engine designer as well as an inspired tinker. Right through the book one feels—as did Samuel Pepys when reading " a letter of advice to a courtier "—inclined to " tear out the leaves it was writ in." The present reviewer would, indeed, advise all readers of this book to do so pencil in hand, and since much of the writing is in what might almost be called technical epigrams, the pencil will be kept busy. Many readers are sure to find particular nourishment in the two chapters headed " Mechanical Design," and it is no mean tribute to the author to affirm that anyone reading his sentences on the torsional vibration of crankshafts (pages 230–237) will be the better for it. A special interest attaches to what Sir Harry Ricardo writes on the subject of the evolution of the sleeve-valve engine in the Knight double-sleeve design of 1908 and the Burt single-sleeve design of 1910. One wonders to what extent high-speed engine practice might have been influenced had the Burt-Argyll six-cylinder sleeve-valve engine of 1914 not broken its crankshaft prior to the completion of War Office trials. Reading Chapters XVII and XVIII one feels that here is the authentic history of a great effort. Typical of the author's outlook is the first sentence of Chapter XVIII, which relates to two-stroke sleeve-valve engines : " The author's excuse for including this chapter which deals with an investigation that unfortunately bore no fruit is that the data and experience gained from it may be of interest, and possibly of use, to others." We do not remember reading anything which rings more clearly of sheer research experience than does this chapter and to pick out an illustration we may quote the author's reference (page 386) to one phase of the research : " During part of the period a supercharged four-stroke sleeve-valve unit, of the same cylinder dimensions as the ' E65s ' was run in parallel with the two-cycle units. This had virtually the same shaft and bearing dimensions, and it was noteworthy that the four-stroke engine knocked its bearings about much more severely than the two-stroke units, although the latter were developing double the power."

While in this book the author deals exclusively with the high-speed engine and illustrates no unit with a cylinder size larger than 7½in by 12in, users of medium and slow-speed engines will find their particular problems illumined by the experience of a great researcher whose apparatus has been actual engines, whose laboratory has been the test floor and whose every statement is a reflection of experience. There is no detail so small as to escape his attention and one feels that great pains have been taken to arrive at a text which will be of maximum value to the reader, whether his work is to design, manufacture or operate high-speed internal combustion engines. It was said by R. L. Stevenson that in literary work he could always detect the evidence of " elbow grease " or the lack of it. One feels that in this book Sir Harry Ricardo has not spared himself the effort which must be expended by any writer who aims not only at expounding a subject, but succeeds in illuminating it with the bright light of his own experience.

British Gear Manufacturers' Association

The ninth annual general meeting of the British Gear Manufacturers' Association was held at the Piccadilly Hotel, London, on Tuesday, May 19th. A technical discussion followed. Mr. A. Sykes introduced the subject of gear shaving and Mr. A. H. Orcutt that of gear grinding. At a subsequent luncheon Rear-Admiral (E) A. D. McGlashan proposed the toast of the Association. He referred first to the shortcomings of anti-aircraft fire in the last war and said there had been much improvement since. The Navy was searching for equipment of no weight and occupying very little space that shot twice as fast and could not miss ! The problem was to control a missile 20,000 yards away from a 6ft diameter platform and there were something like 100 different gears in the control chamber. About thirty of them needed to be made to the Admiralty's classification I, fifty-five to classification II, ten to classification III, which corresponded to instrument gears and only five to ordinary commercial standards. It was a matter of great regret to him that gear-making machines suitable for making gears to the Navy's high standards were not readily available in this country. British Standard specifications referred to relatively low-grade gears. The Admiralty had invited the industry to criticise the Navy's specification in four grades. Mr. Sykes, Chairman of the Association, replied. Mr. E. O. Liebert then proposed the toast of the Guests to which Dr. T. W. F. Brown, research director of Pamerada, responded.

Books Received

The Power and the Valley. By Henry Billings. London : Rupert Hart-Davis, Ltd., 36, Soho Square, W.1. Price 12s. 6d.

The Road and the Vehicle. By B. G. Manton. London : Edward Arnold and Co., 41, Maddox Street, W.1. Price 30s.

Textbook of Engineering Materials. By Melvin Nord. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 52s.

Higher Industrial Production with Electricity. London : British Electrical Development Association, 2, Savoy Hill, W.C.2. Price 9s.

Power Cables : Their Design and Installation. By C. C. Barnes. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 35s.

The Steam Locomotive in America. By Alfred W. Bruce. London : George Allen and Unwin, Ltd., 40, Museum Street, W.C.1. Price 45s.

A Review of Metallurgical Developments

By Dr. L. B. PFEIL

In the presidential address to the Institution of Metallurgists, delivered on May 13th, from which extracts are here printed, Dr. Pfeil reviewed some of the metallurgical developments that appealed to him as outstanding during the last thirty years. He pointed out how much those developments have influenced engineering design.

As a student I recall being taught that "metallurgy is the art of extracting metals from their ores at a profit." This was not then far from the truth; in the early part of this century metallurgy, beyond the field of extraction, consisted largely of the isolated study of the behaviour and uses of individual metals and alloys. How different to-day, when the investigation of general principles controlling the behaviour of metallic materials is the basis of metallurgical science!

Constitutional study of alloy systems has now come to be the recognised method of initiating the development of materials having specific properties, and it is to the comparatively recent improvement of radiographic and micrographic methods, magnetic, electrical and other physical tests, and even the development of radio-active tracer technique, that we owe the value of this approach.

Use of physical methods has made an important contribution to the investigation of age-hardening, a phenomenon which, although well established by the researches of Wilm, Merica and Rosenhain and his colleagues, as occurring in aluminium-base materials, was in the 1920s still somewhat of a metallurgical curiosity. The past thirty years have seen the fundamental researches carried out by Gayler, Guinier, Preston, Fink and Smith, and others, and have also witnessed the application of precipitation hardening to copper and copper alloys, austenitic nickel-chromium steels and high-temperature alloys. The mechanism of the process, the influence of critical states of dispersion, and the interrelation of precipitation characteristics with other physical properties have thus become sufficiently well understood to make precipitation hardening a regular tool for use in producing materials to specification requirements. As Mehl has remarked, "the possibilities of producing age hardening are ubiquitous and the phenomenon can be invoked by the metallurgist in alloy development with remarkable freedom."

Advances in the knowledge of precipitation hardening have been paralleled in the ferrous field by expanded knowledge of the decomposition of austenite, the mechanism of martensitic hardening and other transformational phenomena in steel. The early years of the century had seen much interest in this subject, but, from the speculations which had then been made, we have travelled a long way. By dint of dilatometric, metallographic, magnetic and other methods of study there has now been acquired a fund of basic information which is being utilised in the heat-treatment of steel. In 1929 Bain and his colleagues embarked on a series of investigations on the isothermal decomposition of austenite, the results of which were destined to have far-reaching effects in all countries. As a result of their early work the now-familiar *S*-curve was produced. Later work by these investigators, and by others in all the principal countries of the world, has gone far towards explaining the characteristics and mechanism of transformations in steel.

Turning now to metallurgical products of which the usefulness has been enhanced by new methods of extraction and refining, modifications in composition, and improved processing procedure, copper comes immediately to mind. Voce has recently called attention to the surprising fact that a very large proportion of the knowledge which has had so important an effect on the expanded use of this very old metal has been developed during the past two or three decades. Apart from the old-established brasses, bronzes and gun-metals, the 80–20 and 70–30 cupro-nickels and the nickel silvers, almost the whole of the extensive series of copper-base alloys now at the service of industry has been born within the past twenty to thirty years. To mention only two or three typical cases, special grades of high-conductivity alloys, such as cadmium-copper, silver-copper and tellurium-copper, now offer a range of materials combining the electrical conductivity required for specific purposes with other characteristics such as higher tensile strength, raised softening temperature, or improved machining qualities, all of which were unattainable in earlier grades of high-conductivity copper-base alloys. Again, in the 1920s, the aluminium and nickel-aluminium bronzes were only beginning to claim some recognition in engineering circles. To-day, such alloys are in use for marine propellers weighing up to 20 tons, and for many other parts in which a combination of strength and corrosion-resistance is required.

One of the most spectacular developments in copper alloys during this period has been in condenser tubing. The stage of development reached to-day makes the "condenseritis" of Admiralty brass tubing during World War I sound almost unreal. The introduction of cupro-nickel and aluminium-brass condenser tubing represents a major contribution of metallurgy to marine engineering. With these developments, and with the more recent introduction of the iron-containing cupro-nickels we, of course, associate the names of our honorary treasurer and his colleagues at the British Non-Ferrous Metals Research Association.

Aluminium could almost be classed as the "wonder-child" of the period under review. In the early days of the industry there was little demand for the pure metal and the combinations of properties which could be obtained by alloying it with various other elements were then unrealised, but after the discovery of the age-hardening capacity of aluminium-base materials, intensive research and development revealed their useful qualities and consumption rose, at first gradually, and then, during the period 1930 onwards, to a spectacular extent, in step with the growing importance of the aircraft and automobile industries. The high mechanical strength which can be developed in the light alloys has led to an unprecedented variety of applications in aircraft, automobile, railway, structural mining, and marine engineering. The rise in production which has taken place during recent years may be appreciated from the fact that statistics at present available indicate that in 1952 production of aluminium in the free world exceeded the combined volume of the older non-ferrous metals—copper, lead and zinc. In the electrical industries also, aluminium has important and developing applications, due to its high electrical conductivity; an example which is very obvious in this country is the thousands of miles of steel-cored aluminium overhead conductors embodied in the grid system. A recent application is for the sheathing of electric cable, which promises to effect economies in electrical transmission and distribution. The principle of cladding has been applied with peculiar success in aluminium products.

Nickel-containing alloys also claim a place in the category of materials known in the 1920s, but developed, modified and extended in use during the past thirty years. Nickel-copper alloys of Monel and cupro-nickel types, nickel-chromium alloys for electrical resistors and nickel silver broadly represented the range of nickel-containing alloys which could be said to be of commercial interest in the early 1920s. The unusual physical properties of the nickel-iron series had already been investigated, but the practical application of these properties was not yet widely established on a commercial scale. From this broad background there have been developed, as the result of much detailed research, materials having highly specialised properties, varying over a wide range.

In the nickel-rich alloy field the application of precipitation hardening has played a not inconsiderable part—for example, in K-Monel and S-Monel hardened with aluminium and silicon, respectively. More recently precipitation hardening has been applied effectively to nickel-chromium scale-resistant alloys to develop high creep resistance. This conversion, from the familiar resistance wire in the electric fire to the Nimonic combustion chamber, sheet metal and blades used in the gas turbine, results from the addition of titanium and aluminium in quantities up to 3 per cent to the 80–20 nickel-chromium base, the resultant stiffening being attributable to the precipitation of a titanium-rich phase. Accordingly, the application of the correct heat treatment is vital to success.

The nickel-iron alloys have grown rapidly in industrial importance within the past thirty years. The researches of Guillaume on "anomalies" in iron-nickel alloys was published in 1917, but it was only much more recently that large-scale use was made of the unique and controllable thermal-expansion properties characteristic of 36 per cent nickel-iron and related types of alloy. To-day their application is widespread, in many types of temperature-control device and other forms of precision mechanism. The nickel-iron group has also come into prominence in connection with its unusual magnetic properties. With nickel in the range 35 per cent to 80 per cent magnetic permeability becomes very high and alloys in this range are now important in the electrical engineering industry, for loading of cable and for relays, amplifiers and other components used in telecommunication equipment; also for such apparatus as measuring instrument transformers and magnetic shields, in which magnetic "softness" is a primary requirement. Among the nickel-iron base alloys may be included the magnetically "hard" group, containing aluminium as an essential addition, with or without cobalt, copper and other elements. Such alloys, discovered by Mishima in 1932, were subsequently developed intensively in England, U.S.A. and other countries. The

high energy per unit size obtainable makes possible the use of a very small volume of material. One of the first important applications of the aluminium-nickel-iron base type of magnet was in loud-speakers of radio sets and they are now used with success in many other electrical devices, such as indicating instruments, watt-hour meters, magnetos, &c.

Cast iron has, during the past thirty years, been developed and improved to an extent which makes the modern engineering irons scarcely recognisable as being related to the earlier types. The advances which have taken place, in methods of production and treatment, and by means of alloying, are strikingly illustrated by British Standard specifications issued at various stages over this period. Whereas in 1928 the first British Standard covered only two grades of cast iron, having, respectively, tensile strengths of 9 and 11 tons per square inch, improvements in foundry technique had by 1938 made possible specification of " high duty " iron castings of three grades, of 14, 17 and 20 tons tensile. In 1941 a new 23-ton grade was standardised, and in 1945 a composite specification was drawn up covering various grades ranging in tensile strength from 10 to 26 tons per square inch. Nor should the " special " grades of cast iron be omitted, since these materials (such as the austenitic corrosion-resisting and non-magnetic types) have been developed mainly within the past thirty years, and their advent has widened the scope of application of cast irons far beyond limits foreseeable in earlier years. Finally, an important development in this field has been that of the " spheroidal "—or " nodular "—graphite cast irons, in which, by treatment with magnesium or cerium, the flake-graphite structure which is characteristically associated with brittleness in cast iron is changed to a spheroidal form which is accompanied by toughness and ductility never before attainable in cast irons. This development, which is still the subject of intensive study, is at present in its early stages, but there is already ample evidence of its practical importance to the engineering industries.

Some mention must be made of the stainless steels which, although firmly established by the early 1920s, have been the subject of much study in later years, with resultant increased demand. The chromium-nickel austenitic steels are, of course, the most interesting group, both from the point of view of their constitution and properties, and by virtue of the very wide range of uses to which the various grades can be put. Recent developments in chemical engineering and in the oil industry are creating an ever-growing demand, but it is also interesting to note the potential value of the stainless steels in structural engineering, and in other applications in which there is a call for good mechanical properties combined with corrosion resistance. The development of precipitation-hardening grades of stainless steel, containing copper, aluminium, titanium, &c., has still further widened their sphere of usefulness. One may hazard the guess that future decades will witness increased use of the austenitic steels in fields outside that of chemical engineering.

Much progress has been made during the past thirty years, in methods for the production of metal powders of controlled particle size and characteristics, and development has been substantially assisted by knowledge acquired through studies of diffusion, and by the use of physical and physico-chemical methods for determination of particle size and other properties. Magnetic cores, permanent magnets, alkaline accumulator plates, and hard-metal alloys are among the items now being made from powders, and recent research has shown that the technique may have additional value in facilitating strict control of composition and resulting physical properties.

As I prepared the notes for this address, I became increasingly impressed with the debt we owe to the many technologists whose names have never become prominent. Much of the progress made during the last three decades has been due to the work of these men, who did not seek fame, but had for incentive that professional pride which led, also, to the formation of this Institution.

Iron Powder Magnets

A new kind of permanent magnet, made from soft ferromagnetic powders, is now being manufactured in Great Britain. These magnets are moulded under pressure, the raw material being very fine powders of iron or iron alloys, known as micropowders. The micropowders are produced by low-temperature chemical reduction, from iron compounds, and the properties that make them suitable for permanent magnets spring from the fineness of their particle size. This article gives some of the characteristics of micropowder magnets in comparison with other commercially available magnetic materials.

COMMERCIAL magnetic materials fall into two broad groups : the first includes sheets with low electrical losses made to be stamped into laminations which are therefore soft mechanically, and the second includes permanent magnet alloys with high magnetic hysteresis loss which are usually physically hard. From this general classification the two groups have become known respectively as " soft " and " hard " magnetic materials. The fact that satisfactory permanent magnets can now be made from pure iron, hitherto the classic soft magnetic metal, is, therefore, an unexpected development. It is achieved by converting certain chemical compounds of iron into very fine metallic powder by a hydrogen reduction process at low temperatures, to obtain a particle size much finer than any hitherto produced in quantity. Pure iron powder made by such processes is soft mechanically and can be moulded without a binder into solid and stable permanent magnets with an energy factor equivalent to that of the best cobalt steel, but with nearly half the physical density. The reduction of chemical compounds at higher temperatures can be used to produce both pure iron and iron-alloy magnetic materials with low losses which have important applications in many branches of the electrical industry. Because of the similarity of the processes to obtain what appear to be contrary results, it is desirable to describe briefly the present state of progress in the field.

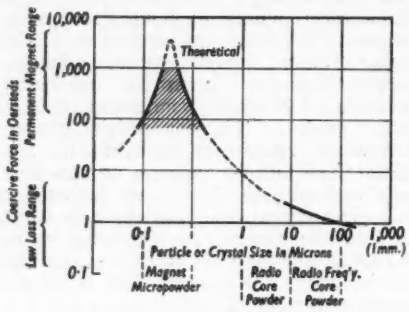


Fig. 1—Relation Between Particle Size and Coercive Force

The first magnetic alloy powders to be made by chemical reduction methods were prepared by the research laboratories of the General Electric Company, Ltd., about twenty-five years ago, and this process was developed to a production and commercial scale by the associated company, Salford Electrical Instruments, Ltd. The advantage of this method of making magnetic powders in comparison with others now in commercial use is that the chemical method makes it possible to produce powders of pure iron and of a wide range of alloys with any required particle size by careful control of the raw materials used and the temperatures employed in manufacture.

Recent developments have extended the particle size ranges of the powders produced therein to the degree of fineness necessary to give high coercive force and these very fine powders are generally known as micropowders. Micropowder magnets were first developed and patented by the French metallurgical company, Société d'Electro-Chimie d'Electro-Metallurgie et des Acieries Electriques d'Ugine, and " Gecalloy " micropowder magnets are being made under licence in Great Britain by the Salford Electrical Instruments, Ltd.

Micropowders

It has been known for some years that the coercive force of iron powder is partially dependent upon particle size. From the development of the domain theory it was deduced by Professor Neel, of Grenoble University, during the last war that very fine particles of the order of magnitude of a magnetic domain would exhibit very high coercive force exceeding any value hitherto obtained in conventional magnets. The required optimum particle size was about one-hundredth that of the finest powder hitherto made for radio cores, and the preparation, even on a small scale, was difficult and hazardous because such powder has an extremely strong affinity for oxygen and spontaneously oxidises when exposed to the air. The magnetic quality of this highly pyrophoric powder could be maintained only by immersing the micropowder in inflammable liquids such as benzine which tender to increase the hazard.

It was found experimentally that coercive forces approaching 1000 oersteds could be obtained from pure iron reduced in dry hydrogen from ferrous formate and the best results were obtained with a particle of crystal size of 0·01 to 0·1 micron (1 micron=0·001mm). Below

Fig. 2—Mixing the Magnetic Powder

this critical size range the coercive force is rapidly reduced to figures inadequate for permanent magnets. In theory the maximum coercive force of pure iron approaches 10,000 oersteds, assuming that the particles are elongated and of optimum dimensions oriented in one required direction.

These figures with the appropriate particle size range are shown diagrammatically in Fig. 1, which indicates approximate values of coercive force plotted on a logarithmic scale. This diagram shows how the same raw material, pure iron, in powder form can give two grades of magnetic material with the opposite characteristics. The coarse range above 1 micron is of practical value on account of its low loss and the micropowder range below 0·1 micron gives useful permanent magnet properties.

Improved magnetic performance is obtained by using micropowders of certain magnetic iron alloys which can be produced by similar chemical processes to those used for low-loss "Gecalloy." In practice, the best results are obtained by making magnets from an iron-alloy micropowder containing 30 per cent cobalt, but, because of the high price of this metal, cheaper grades are made with lower percentages of cobalt or from pure iron prepared from less expensive raw materials. This fact has become significant during recent years when cobalt, which is used in large quantities for most kinds of steel magnet, has become scarce because of strategic demands.

Micropowder Magnets

Permanent magnets are made from micropowders by high pressure moulding which increases the remanence in proportion to the physical density. This factor is also important in connection with the mechanical strength of the magnet, although improvements can be made by the use of plastic binders. Magnets are being made in quantities from these materials with a density of from 4 to 5 grammes per cubic centimetre. This is about 40 per cent reduction compared with the density of most steel magnets and represents an important advantage to the designer and user. It also represents a considerable material economy because a ton of micropowder will produce nearly twice the number of magnets compared with a ton of steel; the relative magnetic energy for the same raw material is discussed below.

For those purposes where high remanence is required, the micropowder magnets can be pressed alone and will have a low material resistivity, but if a suitable binder is used, the resistivity can be increased almost to any required value. This problem has been very fully explored in connection with the manufacture of low-loss powder cores and the wide experience obtained has been applied to micropowder magnets with useful results. This is a clear indication of the very close similarity between the two groups of material on a practical scale.

Magnetic Properties

The energy factor of a permanent magnet (BH_{max}) expressed in mega-gauss-oersteds) represents the maximum external energy which can be maintained by each cubic centimetre of magnet.

The best micropowder now available consists of an alloy of 30 per cent cobalt and has an energy factor of 1·7, which is equivalent, among the conventional magnet materials now on the market, to that of Alnico (13 per cent cobalt, 10 per cent aluminium, 18 per cent nickel, 6 per cent copper, 53 per cent iron). In chemical composition this 30 per cent cobalt micropowder with a density of about 4·5 grammes per cubic centimetre is equivalent to the best cobalt steel which has an energy factor of only 0·95 and a density of 8·1 grammes per cubic centimetre, giving an advantage of over 3 to 1 in raw material utilisation. The lowest grade of micropowder magnet now being made has an energy factor of 0·5 and is thus equivalent to 9 per cent cobalt steel in magnetic energy.

From these figures of merit alone it will be seen that the general quality of micropowder magnets is about the same as for the range of permanent magnets available just before the last war. They all give the stated magnetic properties in each direction and so are known as isotropic or non-directional magnets. Since that time the introduction of Alcomax cast magnets with strongly directional properties (anisotropic) has resulted in a threefold increase in energy factor, principally in remanence. These advantages can, however, be obtained only in certain designs and particular conditions, so that there is still a considerable demand for the isotropic magnets with lower energy factors.

One of the chief advantages of micropowder magnets in comparison with others is the control of the ratio of remanence to coercive force (or permeability) over a wide range. The present range of steel magnets gives properties which are closely restricted to the alloy and method of manufacture used. For this reason a wide range of alloys is listed, to give the diversity of properties required by the equipment designer. With any particular kind of micropowder, on the other hand, it is possible to control readily the physical structure by varying the manufacturing technique to give permeability values from 50 to 5, in order to meet the diverse practical demands.

A suitable plastic binder is useful to maintain the mechanical strength of high coercive force grades of micropowder magnet in which the physical density is low and this imparts the great advantage of very high resistivity to the magnet. Although this advantage applies to oxides and ferrite magnetic materials, this is the first time it has been obtained with metallic magnets, and it opens up extensive possibilities of their use under alternating current conditions. Perhaps the most important requirement of a permanent magnet is high stability and constancy of performance throughout life and under severe operating conditions. These are obtained by using material with suitable coercive force and the range of over 350 oersteds has been found satisfactory in this respect for various types of magnet. Stable physical structure of the magnet is also required and micropowder magnets with a coercive force range of 400–700 oersteds have been found to give adequate stability.

Production Methods

Because of the softness of micropowders it is possible to mould them into magnets to accurate dimensions without final grinding. Moreover, the up-to-date powder metallurgy methods can be used for quantity production. But, whereas in conventional powder metallurgy the powders are heated at high temperatures to make the pressings mechanically strong and dense, micropowder magnets are made at low temperatures; therefore, it is possible to include shafts, pole pieces or inserts of various other metals into the mouldings. For small quantities and samples, micropowder magnets and magnet systems are made by shaping and grinding pressed compacts to the required design.

The main stages in the manufacturing are here briefly outlined, and some of the processes are illustrated in Figs. 2 to 4. The micropowders are produced by low-temperature chemical reduction of iron compounds. After receiving its insulating coating the powder is mixed in a conventional dough mixer of the kind used in bakeries, except that in the process now described heat is applied by burners below the container, as shown in Fig. 2. The magnets are moulded in conventional power presses, examples of which are shown in Fig. 3.

After pressing all micropowder magnets are sprayed with a green coloured plastic which gives a smooth finish and protection against corrosion. After being sprayed the magnets are dried in infra-red ovens. In Fig. 4 we show ring-shaped micropowder magnets on conveyor-driven trays entering infra-red drying ovens.

By using suitably designed dies and moulds it is possible to produce permanent magnets in a great variety of shapes and sizes. With this technique it becomes feasible to mould complete magnetic systems embodying pole pieces and inserts. Facilities such as this offer scope for making a new approach to the design of certain electromagnetic components and assemblies such as those associated with very small motors and loudspeakers, microphones and ear pieces. Here the use of micropowder magnet systems, having high resistivity and small eddy current loss, opens up the possibility of improvement in performance.

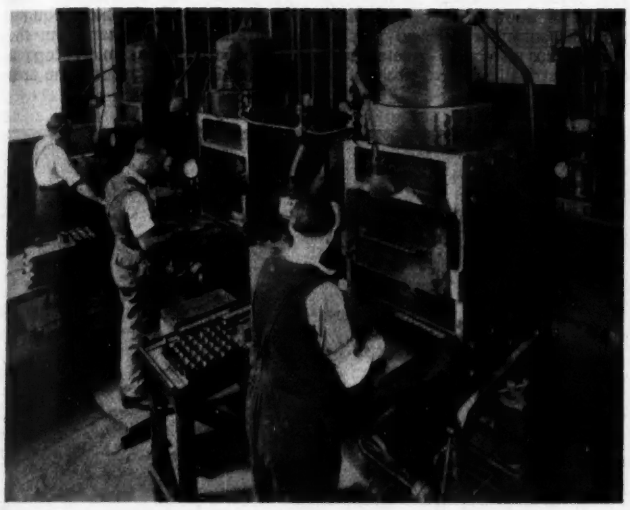


Fig. 3—Power Presses Applied to Production of Micropowder Magnets

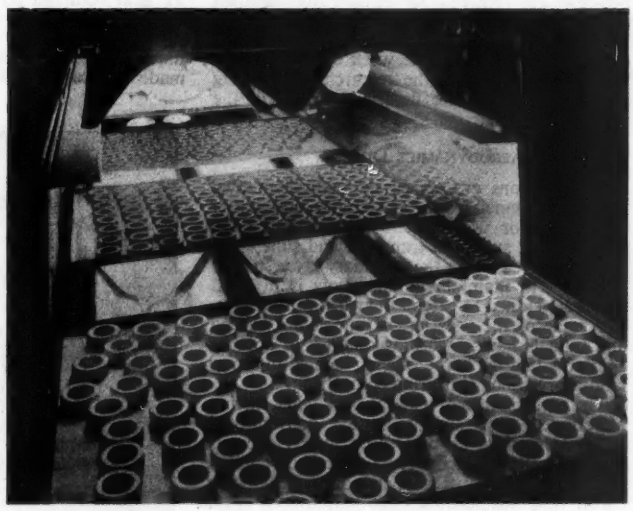


Fig. 4—Infra Red Drying of Micropowder Magnets

The National Physical Laboratory

THE annual open day at the National Physical Laboratory, Teddington, was held on Friday, May 15th, when representatives of research associations and Government departments and members of the research staffs of industrial firms were able to visit the laboratory. This day, set aside annually, gives an opportunity for all those interested in research, and particularly the work carried out at Teddington, to see exhibits illustrating current activities and to witness demonstrations of various items of research equipment. The scientific work of the laboratory is conducted in eight divisions and in addition there is a separate section for electronics. Exhibits showing examples of basic research and of applied technology were arranged in each division and members of the staff were in attendance to amplify the explanatory notes attached to the exhibits and to discuss cognate problems. During such a brief visit it is not possible for visitors to make any detailed examination or enter into discussions of specific technical problems, but they can see something of the broad scope of the work covered by the laboratory. Some of the research items being studied at present are described briefly in the following notes.

Aerodynamics Division

Investigations are concerned with theoretical and wind tunnel work on stability and flutter derivatives for wings of swept-back and delta planforms at subsonic, transonic and supersonic speeds. Research on the boundary layer suction on wings to maintain laminar flow is in hand and it is planned to extend the work to fuselages. For some of the tests larger tunnels are needed and tunnels having working sections of 36in by 14in and 25in by 20in are being erected in a new laboratory which is nearing completion.

The performance of a swept-back wing, having a rounded nose similar to the conventional subsonic section, at supersonic speeds depends on the suction which occurs over the rounded leading edge, because high suction over the wing chord near the leading edge will reduce drag. To compare the actual flow near the leading edge with that predicted by theory experimental observations are being taken, including measurements of pressure at the wing surface, of lift, and of the drag and pitching moment, by a strain gauge balance. This equipment has been developed to measure three components of the aerodynamic force acting on a model in a supersonic tunnel and electric signals from the resistance gauges, cemented to the model support, record the component forces.

To obtain satisfactory performance at high speeds thin wing sections having a thickness lying between 8 to 10 per cent of the chord have been adopted. Thinner wings may be adopted in the future and tunnel tests are in hand to gain knowledge of the flow past such wings; at present wing sections from 6 to 3 per cent thick are being tested. Recent experiments on the interaction between shock waves and boundary layers have taken place in a special tunnel which enables the Mach and Reynolds numbers to be varied, and a demonstration showed the effects of changes of Reynolds number on the flow near the base of a two-dimensional wedge held in a supersonic stream. A high precision method of making two and three-dimensional aerofoils for high-speed tunnels has been developed and other work carried out was the testing of prototype military and civil aircraft in the compressed air tunnel.

Electronics Section

The ACE automatic high-speed digital computor has a storage capacity of about 13,000 binary digits and to augment this to a total of over 100,000 large numbers each of ten numbers or more, a synchronised magnetic drum digital storage system is being developed. The drum is 4in in diameter by 4in high and has sixteen reading and sixteen writing heads, both sets being arranged to shift axially so that thirty-two tracks are available in the drum. Each track can carry thirty-two numbers so the total memory capacity is 1024 numbers, each equivalent to 10 decimal digits. The speed of the drum is synchronised with the rest of the computer and controlled to a constant value, its position being determined at every instant to within one five-thousandth of its circumference.

Light Division

This division has developed and improved methods of producing diffraction gratings by use of the Merton nut and has made exceptionally accurate linear scales by flash projection of the image of a slit on a photographic plate advanced by a Merton nut. The method used for making diffraction gratings is now in more general use and examples are shown of the accurate measurement of length by an electronic counting technique and the production of the slow uniform rotary movement required in optical instruments. To deal with the problems of colour measurement caused by the introduction of fluorescent inks and pigments a successful measuring technique has been developed. Progress has also been made with regard to transparent electrically conducting films on glass. Remarkable results have been obtained with gold films on a layer of bismuth oxide and they transmit about 75 per cent of white light. Other work is related to the measurement of the distortion of wavefronts by parallax and stereoscopic methods and the department has evolved an examination method for the more accurate evaluation of the shape of an optical wavefront. The new development enables variations of height on the surface of a mirror of 4×10^{-6}in to be distinguished.

Model for Side Launching Investigations

Metallurgy Division

Investigations have shown that the removal of phosphorus made incompletely hardened steel as strong as hardened steel having the normal phosphorus content and it has been found that iron containing small amounts of carbon is tough at low temperatures and has high yield stress when rapidly cooled from 900 deg. Cent. The brittle fracture of ship plates has stimulated interest in their ductility properties and a study is being made of the cleavage strength of iron crystals to understand the mechanism of this form of failure. Single crystals made by the strain and anneal method and electrolytically machined are cooled in Dewar flasks and tested and broken in a Chevenard tensile machine, and the orientation measured by an X-ray method. The crystals over a wide range of orientation are still ductile at −196 deg. Cent, but may change to brittle behaviour if the cleavage plane is inclined to the stress axis at less than 80 degrees. Other work on iron is an investigation into the properties of quench low carbon material.

The melting point of titanium has been investigated to check American results and a technique has been devised to reduce contamination of the molten metal while the melting point is determined under approximately black body conditions. The mean value obtained is 1660 deg. Cent. and is considered accurate within ±10 deg. Cent.

For the investigation of the properties of tilt boundaries in metal crystals, an apparatus has been constructed which allows the position of the tilt boundary to be continuously observed as the crystal is deformed at creep rates of strain or under cyclic stressing. In the electron microscope it is difficult to identify a predetermined area of a specimen due to the high magnification limiting the field of view, and the metallurgical division has overcome this difficulty by the development of a simple method which requires no precision apparatus. After examining the metal surface under an optical microscope a circle of $\frac{1}{8}$in diameter is drawn around the area to be examined and a replica of the surface floated in a beaker of water and viewed by optical microscope. The specimen grid, consisting of $\frac{1}{4}$in diameter copper disc with about 200 holes to an inch, is positioned under the replica, which is adjusted to lie over a hole near the centre of the grid, then both are lifted from the water. In the electron microscope the centre of the grid is easily located and the particular surface identified.

Metrology Division

A new gauge-measuring interferometer has been made by the department and is designed for routine measurements of gauge blocks of lengths up to 4in in terms of wavelengths of light. The gauges can be set up for measurement on a flat steel rotatable base-plate so that each gauge may be brought to the centre of the field of view for measurement. A mercury −198 lamp and a cadmium lamp are incorporated to provide a selection of monochromatic radiations of known wavelengths in terms of the yard and the metre. Three or four radiations of different colours are used in sequence to illuminate the field of view and a visual estimation made for each radiation of the relative displace-

ment between two sets of parallel interference fringes, one of which is viewed over the upper surface of the gauge and the other over the base-plate. Such estimations can be made to one-twentieth of the fringe spacing or about 0·5 micro-inch and the size of each gauge is derived by comparing observed displacements with standard values and a special slide rule automatically evaluates differences from the nominal gauge length. These results are corrected to the corresponding length at 20 deg. Cent.

To meet the demand for high precision, small metal aerofoils, particularly those of delta wing form, where the section diminishes from root to tip, the division has evolved a manufacturing method consisting of precise rotation and tilt of a blank under a milling cutter set to generate the required tangential planes. The models are made by cutting a number of planes which leave at each intersection a very small amount of excess metal which is removed by fine emery cloth.

Physics Division

High temperature measurements on materials are of importance to the steelmaker and many others, and the N.P.L. has constructed a high temperature calorimeter which consists of a vacuum vessel, water cooled on the outside, with an alumina pot inside which can be heated to 1600 deg. Cent. An alumina crucible inside the pot holds the specimen and between pot and crucible platinum radiation screens prevent heat exchanges as far as possible. The temperature difference between pot and crucible is kept at zero by an electro-pneumatic controller regulating the current to the heaters, so the heat supplied to the crucible all goes to its contents. From the amount of this heat and the temperature rise the specific heat of the contents is obtained. The apparatus is being used to measure the latent heat of melting of pure iron and various steels and also the heats of transformation, from one crystal form to another, of iron and its alloys.

Although it is seldom necessary to cool industrial materials down to absolute zero there is an increasing need to do so in the field of low temperature research. To attain such a low temperature it is necessary to liquefy helium, which boils at −452 deg. Fah., and to immerse the object in the fluid. This demand for low temperature research resulted in the production in America of the Collins Helium Cryostat and this helium liquefying plant has been installed at the N.P.L. and was shown in operation. This plant will be used for the standardisation of thermometers, and in the study of the crystalline properties of metals and also for the measurement of the entropy of pure chemicals.

Ship Division

To extend the knowledge of the frictional resistance of smooth surfaces when towed in water, experiments have been carried out using pontoons having a draught of only ½in, reducing to nil at the ends. The pontoons, of wooden cellular construction, with plastic external covering, are made in units 15ft long by 4ft wide with the end units being 8ft long and having a slight rise of bottom to ensure smooth flow of the water at entry and exit. In this work a maximum length of pontoon of over 200ft is contemplated and the tests cover a range of Reynolds number up to about 100 million, so that in conjunction with other work, the Reynolds number covered is from 0·1 to 100 million.

Investigations to determine the effect of the various factors which influence a side launch are in hand and a mock-up to a scale of one-twelfth of the launching arrangements in a shipyard and using a model of a ship having a length between perpendiculars 180ft by 32ft beam moulded by 10ft mean moulded draught was being demonstrated. Triple cradles with brass liners on their lower surfaces support the model and slide over a series of rollers. The model is released by a wire and pulley system in conjunction with a vertical release cam and there is a quick release mechanism, in the amidships cradle, which is activated when the model passes over the way ends. Our photograph reproduced herewith shows the model after leaving the ways. Velocity at any point down the ways is recorded and angular rotation in three mutually perpendicular planes is recorded continuously by triple gyroscopes while the under-water path of the model is obtained by photographic means.

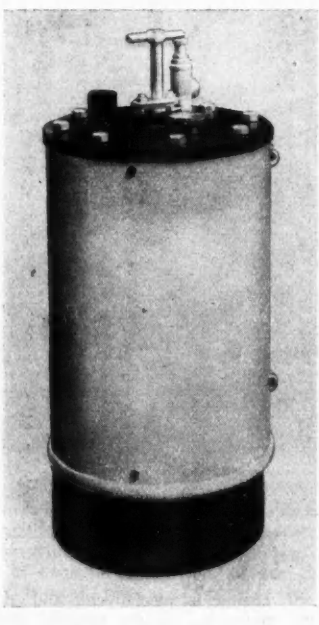
The effectiveness of the rudder in steering a ship is of importance and a technique has been developed for comparing different rudder designs in a model scale. For this purpose a remotely controlled, self-propelled model having a controlled angle of helm is used. The tests consist of setting the model in motion on a straight course down the tank and putting over the rudder at a known rate to a limiting angle. When this angle is reached the helm angle is reversed and the times taken to carry out the operations are noted and the tests are repeated using progressively larger angles of helm.

The problem of creating waves is receiving attention and experiments are in hand with a wave-making model to determine the best shape of plunger for the production of uniform wave trains. Other work in progress concerns hydrodynamic vibration experiments and pressure fluctuations about a rotating propeller, the results of which will have an influence upon the shape of propeller apertures.

A 15kW Electrode Water Heater

Our illustration shows a 15kW electrode water heater designed to supply hot water for space heating and domestic requirements in workshops, offices and private dwellings. This heater is the smallest in the range of "Autolec" water heaters made by G. W. B. Electric Furnaces, Ltd., Dudley, Worcestershire. It occupies a floor space of 15in diameter.

The 15kW heater is a self-contained unit, which has an output of 51,000 B.Th.U. per hour for space heating and can produce 30 gallons of water at 160 deg. Fah. in two and a half hours for domestic purposes. By a simple manual adjustment the output of the equipment can be varied from 10 per cent to 115 per cent of the rated output.

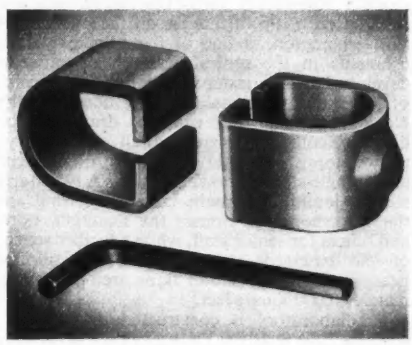


15kW Electrode Water Heater

The boiler shell is lagged to limit the heat losses to about 2 per cent and is equipped with all standard connections, outlets and vent pipes, &c. It is fitted in an outside case finished in cream stove enamel with chromium-plated fittings and there is a dial reading thermometer fitted to the top of the casing which also holds the rating and output controls. The electrode insulators and shrouds are of high tension porcelain and the electrodes themselves are made of corrosion-resisting metal. The rating is governed by the shrouds, which are raised or lowered manually over the electrodes. Temperature control is effected by a thermostat operating a contactor in the main supply. When the water exceeds the desired temperature the contactor is switched out and when the temperature drops, put back again. If required, a room thermostat can be incorporated to override the boiler thermostat.

A Tube Clamp

A tube clamp of simple design which is quick and easy to apply is now being marketed by Supplies and Service Construction Company, Ltd., Artillery Street, Heckmondwike, Yorks, under the trade name "Buildall." This clamp, as can be seen from the illustration below, consists essentially of two high tensile steel pressed members of "U" shape with inturned ends leaving narrow slots. By passing one member through the slot of the other and then turning it the two members can be interlocked, with the passages through which the tubes are passed set at right angles. With the tubes in position a socket head screw at the top of each clamp member is tightened to lock the assembly securely together.



Tube Clamp Members

The clamps can be used both for the erection of permanent racks, guards, &c., and for the quick assembly of tubular members for temporary work. They are made to suit 1in class "A" or "B" standard tubes.

An Industrial Rubber Door

Few parts of any industrial building undergo more severe treatment than swing doors, particularly in places where trolleys, tractors, &c., have to pass through at frequent intervals. For this reason interest will be taken in a design of swing door which is now being produced by William Newman and Sons, Ltd., Hospital

Industrial Rubber Door

Street, Birmingham, 19, in conjunction with the Dunlop Rubber Company, Ltd.

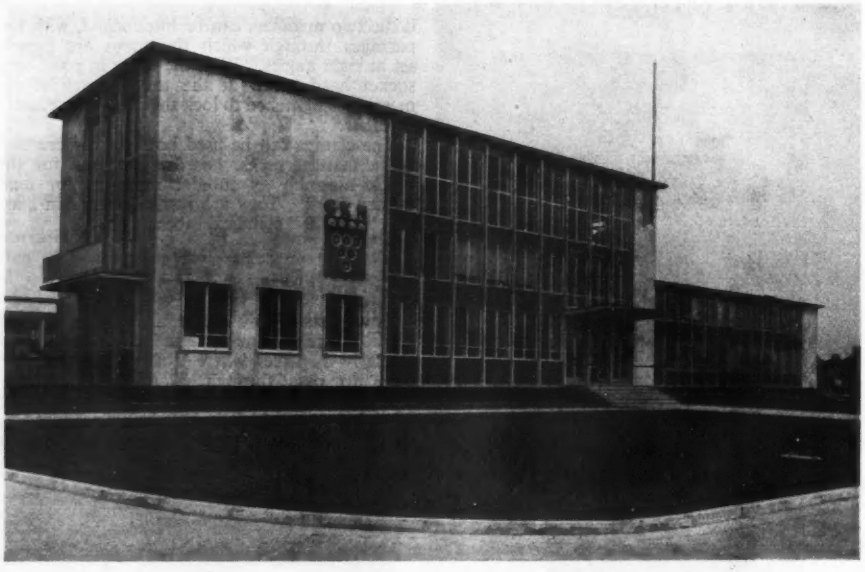
The new door has sheet rubber panels and is designed to swing one way only or both ways as required. A typical door with a tractor passing through can be seen in the illustration on page 743. The door frame of steel tubing is of inverted "L" shape with a triangular bracing plate welded in the corner between the two members. The vertical tube member is fitted close to the side frame of the door and is pivoted at the top and bottom on axles which are let into the lintel and the floor. Enclosed within the top of this tube is a return spring for closing the door.

The rubber door panelling bolted to the top and side tubular frame members is made from $\frac{1}{16}$in thick canvas reinforced rubber, the rubber face on each side being $\frac{1}{16}$in thick. An observation window of transparent plastic material are let into each door panel at a convenient height. It will be seen from the illustration that the panelling is sufficiently stiff to distort slightly before the door swings open under pressure exerted on its lower part. Hand pressure at normal level opens the door in the usual way with but little "give" on the part of the panels.

A Group Research Laboratory

LAST Monday we were able to visit a research laboratory of the Guest Keen and Nettlefolds Group of companies, which has been recently completed. This laboratory, which is situated on a site of 9 acres on the outskirts of Wolverhampton, is one of the principal establishments in the central research organisation developed by the group. The building consists of three main sections, the front administrative block containing the canteen, drawing-office, director's office, conference hall and library; a two-storey laboratory wing with basement, and a single-storey workshop wing. A two-storey section joining the main laboratory wing and the workshop area houses the materials stores and offices for senior staff, while a further section of the basement accommodates the oil-fired heating plant. The total floor area is approximately 40,000 square feet.

The laboratory is constructed of reinforced concrete and rests for the main part upon deep piles, the single-storey wing being built on a concrete raft. We also noted the use of single isolated piles reaching from the foundations as bases for sensitive instruments. Water, gas and compressed air are piped throughout the building, and, in addition to the normal electrical services, points in most of the individual laboratories are wired back to a central control board, from which can be selected a wide range of both a.c. and d.c. supplies.



Group Research Laboratory

Although the design preceded the Festival of Britain Exhibition, the interior layout, lighting arrangements and furniture are reminiscent of the style fostered there.

The main functions of the laboratory include research and development work of direct and immediate interest to group firms on processes and materials, and to advise and develop where required methods of materials testing. It is also engaged on certain long-term fundamental research items.

An active programme on wire drawing aims at the development of techniques which would enable wire drawing to be carried out at the greatest possible speed and with the best possible control of the finished product. The subsequent cold heading operations by which the wire is converted into finished screws, nuts and bolts, are naturally a process which is the subject of fundamental study. This study involves experimental work to determine the forces necessary to reshape the metal, the manner in which the metal flows during the process, and the relation of these results to the mechanical properties of the material. The technique of spark machining used on dies is also under investigation.

Tools and dies are an important ancillary to these operations, and methods of tool design and manufacture, with the aim of producing tools more rapidly and more cheaply, and having longer life are under investigation.

Considerable effort is devoted to the development of chemical, mechanical and physical methods of testing. Every possible analytical and test method is called into play, ranging from the usual machines to determine mechanical properties, to the more high specialised powder X-ray techniques. Non-destructive methods of testing are the subject of active investigation for the detection of flaws and cracks in raw material and in finished components. One apparatus of which a commercial rig is being developed is used for crack detection in socket head screws. The screw is subjected to torsional oscillation and the decay time noted on an oscillograph, a short decay time indicating a cracked product.

In any group involved in the mass production of small components, the necessity to assess the number made at the various stages in the process, and the necessity to batch these components for final sale, make the application of counting techniques of the greatest importance in the interests of efficiency and economy. A great deal of work has been carried out and installations completed to enable products to be counted as they are made, and to enable products to be batched in definite amounts, at high speed, into packages. One mechanical installation working on an impulse principle in conjunction with an epicyclic train counts the stock feed impulses and is thereby independent of the length of the feed.

In the electrical counting machines the product is made to slide in a chute through an induction coil.

A study is being made of the methods of production of silicon iron sheet, while more fundamental background research on the material itself is in progress. Methods of rolling and of heat-treatment have received particular attention. More fundamental work is concerned with the iron-silicon-carbon phase diagram, and with the determination of the effects of impurities in the material. This work requires a detailed study of the best methods available of determining electrical and magnetic characteristics, and some notable methods have been developed at the laboratory.

The workshop is well equipped to carry out its main function of providing necessary experimental equipment for the laboratory, and to a lesser extent specialised mechanical test equipment which is manufactured for group firms. The electrical constructional workshop has provided a considerable amount of equipment for counting and electrical testing, in which sphere the laboratory accepts responsibility for design, manufacture, installation and maintenance. The high quality of the design and constructional work has proved that electronic equipment can be designed to operate with very little trouble under the adverse conditions which frequently prevail on the shop floor.

Improvement Schemes on British Railways

THE British Transport Commission has authorised British Railways to proceed with three major improvement schemes to cost nearly £4,000,000 in all. One of these schemes is in connection with the widening of the East Coast main line by providing two additional tracks between Greenwood signalbox and Potters Bar station. The work will cost £1,750,000 and includes three new tunnels, the reconstruction of Hadley Wood station, the removal of the Greenwood signalbox and the extension of the colour-light and track-circuiting installations. Work on this scheme is expected to start early in 1954 and will take some five years to complete. A scheme for modernising the Crewe North motive power depot will cost nearly £1,000,000. At this depot, where between 120 and 150 locomotives are normally stationed, there have already been provided a reinforced concrete coaling plant of 200-ton capacity, a new mechanical ash-lifting plant, ash pits, a 70ft turntable and a sand drier, but modern buildings are now to be erected on a site to the south of Crewe station for the periodical examination and repair of locomotives. A round-house locomotive shed with thirty-two roads is to be built around the new 70ft turntable, and another similar round-house, also with 70ft turntable, will be provided; a second coaling and ash plant will also be installed together with office and staff accommodation. For this certain track alterations will be necessary. Under the third scheme a motive power depot costing £1,000,000 is to be built at Thornaby, near Middlesbrough, to replace the seventy-years-old depots at Middlesbrough and Newport. This new depot will have two round-houses, each with a 70ft turntable, and when in full use will have an allocation of 220 locomotives.

A COMPARATOR FOR ELECTRODES.—The British Welding Research Association has now made available for general sale a comparator for mild steel metal arc electrodes, which was originally produced for members of the Association. This comparator provides a quick and easy method of presenting to welders and designers the basic characteristics of the electrodes as specified by makers in accordance with B.S. 1719. There is given the essential information on the coating, position, current and voltage for given electrode groups. The comparator can be obtained from the Association's offices at 29, Park Crescent, London, W.1. Price 5s. net.

An Assessment of the Impregnated Pressure Cable*

By L. G. BRAZIER, Ph.D., B.Sc., M.I.E.E., D. T. HOLLINGSWORTH, M.I.E.E., and A. L. WILLIAMS, Ph.D., M.Sc., A.M.I.E.E.†

Since the first commercial installation of impregnated pressure cable in 1940, *about* 140 *feeder miles have been commissioned in Great Britain, and important installations are in progress abroad. Operational experience is detailed in this paper and the prospect of further improvement is discussed. Prospective developments which will assist in improving pneumatic characteristics are indicated.*

THE impregnated pressure cable has certain distinctive features which differentiate it from other types of pressure cable. It has a mass-impregnated paper dielectric which is maintained under a pressure of 200 lb per square inch by means of nitrogen without any intervening membrane, the cable being sheathed and served in the normal manner, but with special reinforcement to cater for the large hoop and longitudinal stresses involved. A full description of the cable has been recorded in various publications.[1] The present paper is based on the experience of one manufacturer only, although the type of cable is not limited to one manufacturer.

The commercial exploitation of the impregnated pressure cable was preceded by several years of intensive laboratory development, including an independent test carried out at the K.E.M.A. Laboratories in Holland in 1937–38. The cable in this case was a single-core, 264kV, 0·65 square inch design; together with its accessories it was subjected to over 400 daily heat cycles at voltages up to 340kV and at a current corresponding to a load transfer of 200MVA at operating voltage. Although this current loading was insufficient to bring about the full conductor temperature rise at which modern installations may be operated, the test was completely satisfactory, no deterioration of any kind being observed, and the K.E.M.A. authorities stated that all tests necessary to prove the cable for service installation at 260kV were complied with successfully.

In 1940, two short runs of single-core, 66kV, 0·75 square inch cable were installed as tie and transfer busbar interconnectors at Battersea power station, followed by 33kV installations at Hams Hall power station and at Blythe Bridge. In 1944, the first three-core, 132kV cable was laid at Burford, in Oxfordshire, marking an important point in cable-making history.[2]

Subsequent development was rapid, and by November, 1952, nearly 150 feeder miles of impregnated pressure cable were in service in this country, particulars of which are given in Table I. (In this, short lengths of single-core cable at the terminations of three-core systems are ignored.)

Reference must also be made to two tests carried out by Electricité de France. In the first of these, a 66kV cable was operated in a 90kV network at Chevilly, Paris. In the second, which is still in progress, a 220kV feeder, complete with joints and sealing ends, is included among the cables undergoing proving tests at the Fontenay testing station. This cable, after having passed all the impulse and alternating voltage tests required by Electricité de France, has since been subjected to a great number of heat cycles with frequent power factor measurements.

The Barking–Ilford three-core, 132kV cable is worthy of special note, since it supersedes the original Burford cable as the self-contained three-core cable with the largest power transmitting capacity yet manufactured.

A recent development is the introduction of seamless aluminium tube as a sheathing material, and about 12 miles of three-core, 33kV cable sheathed with aluminium is now in service. Although the drum length and diameter of cable which can be manufactured in this way are at present limited, the use of aluminium for pressure cables results in a considerable simplification, because the complicated and relatively expensive sheath reinforcement otherwise necessary to withstand the internal gas pressure is avoided.

Although the development of the cable has been entirely British and the system has hitherto found widespread application only in Great Britain, it is now gaining ground oversea. Three Continental manufacturers are now equipped to produce the cable, and an important 240kV installation is in operation in Italy. In addition, installations are pending or in progress in South America, Australia, France and South Africa.

[Here the authors gave details of the cable design.]

ACCESSORY DESIGN

Electrical accessories for the impregnated pressure cable have already been described.[3]

The general arrangement of mechanical and pneumatic accessories is still the same as that described in the paper referred to above.[3]

One important change has been made in the pneumatic design of the three-core straight joint. The modification consists in the introduction of a moulded-polychloroprene "breeches piece" at one end of the joint, making a reasonably (but not perfectly) gas-tight seal between the cable sheath and the insulated cable cores. The purpose of the breeches piece is to subdivide the system into separate pneumatic sections, each consisting of one joint and an associated length of cable. This system of gas channel pipe and breeches piece is of benefit in two ways. In the first place, it reduces the time necessary for pressurising operations, since the system is, in effect, fed simultaneously from a number of points. Secondly, it facilitates the preliminary location of any gas leaks which may occur.

TABLE I—*Impregnated Pressure Cable Installations in Great Britain*

Date	Location	Voltage	Number of cores	Conductor section	Feeder length
		kV		Square inch	Yards
1940	Battersea	66	1	0·75	230
	Battersea	66	1	0·75	280
1941	Hams Hall	33	1	2·0	220
1942	Hams Hall	33	1	2·0	220
1944	Blythe Bridge	33	3	0·15	440
	Burford	132	3	0·4	1,900
	Burford	132	1	0·4	1,900
1945	Upper Boat	132	1	0·4	43
1946	Hams Hall	33	1	2·0	220
	Uxbridge	66	3	0·5	2,000
	Ferrybridge	66	1	0·5	400
1947	Hams Hall	132	1	0·4	612
	N. Tees–Skerneside	66	3	0·2	800
1948	Hams Hall	132	1	0·4	284
	Stagefields–Leek	33	3	0·35/0·4	17,000
	Oxford	132	1	0·4	80
	Stagefields–Bucknall	33	3	0·4	2,011
	Gipsy Corner–Uxbridge	66	3	0·5	19,000
	Bournville	132	1	0·4	400
1949	Birches Bridge–Albrighton	33	3	0·15	8,500
	Barton–Eccles	33	3	0·2	1,500
	Hams Hall	132	1	0·4	338
	Swindon (Staffs)	33	3	0·4	25,000
	Stoke–Longton	33	3	0·4	10,000
1950	Smethwick	33	3	0·4	4,500
	Battersea–Chelsea	66	3	0·4	1,137
	Battersea–Alpha	66	3	0·4	2,260
	N. Hyde–Prebend	66	3	0·4/0·6	46,500
	Battersea–Prebend	66	3	0·4/0·6	32,000
	Battersea–Gipsy Corner	66	3	0·4/0·6	13,000
	Ferrybridge	66	1	0·5	267
	N. Tees–Shotton	66	3	0·25/0·3	3,000
	Kearsley	33	3	0·2	7,000
	East Ham	66	3	0·1	1,622
1951	Ilford–Buckhurst	33	3	0·15	10,700
	Birmingham	33	3	0·3	18,600
	Cheltenham	132	1	0·3/0·45	410
1952	Barking–Ilford	132	3	0·6	17,700
	Hounslow	66	3	0·4/0·6	2,530
	Burslem	33	3	0·4	5,225
	Brunswick Wharf	132	1	0·3	110

THE PNEUMATIC SYSTEM

On a theoretically ideal installation, it would be necessary to supply gas only at one point to build up the pressure, and then the installation could be sealed off. This is the condition in a new installation and it often continues to exist indefinitely, but there is always the possibility that a gas leak might develop, or might be caused by mechanical damage.

Installations are planned, therefore, not only so that they can be maintained in operation under leakage conditions, but also so that leaks can be located as easily as possible and cured. For the purpose of describing the pneumatic system, it is preferable to consider a typical three-core cable installation with straight joints, trifurcating joints and single-core tails to sealing ends.

On systems exceeding about 7 miles in length, gas-feed points are provided at intervals of about 4 miles, and it is usually desirable to separate the 4-mile sections pneumatically by gas sectionalising joints. Within each 4-mile section, at approximately 1-mile interval positions, the gas channel pipe in a straight joint is looped out of the joint and into a "surface box" measuring 12in square and situated in an accessible position. This box contains a simple arrangement of valves which permit the system to be split up into 1-mile sections if the necessity arises, but which are normally open straight through.

The gas feed to the cable is usually supplied to the trifurcating joint at the end of the system, and gas proceeds via the gas channel pipe to the straight joints and thence into the length of cable, which is fed from the joint through an annular space (about $^1/_{32}$in wide) between the laid-up cores and the sheath. The single-core tails have a similar annular space around the core.

The gas-feed equipment consists of one or more cylinders of compressed nitrogen (nominally 2000 lb per square inch) each with its own valve, connected to a manifold and thence to a specially designed two-stage pressure regulator which controls the pressure in the cable. On both the high-pressure and low-pressure sides are connected pressure gauges with signalling contacts. The signal on the high-pressure side is usually set to give a warning if the supply pressure falls to 300 lb per square inch below its original value. On the low pressure side, a preliminary signal is given if the cable pressure falls to 190 lb per square inch, and then a second signal if it falls to the minimum pressure for safe operation, namely 150 lb per square inch. Finally, a safety valve is provided on the low-pressure side to guard against any inadvertent excessive rise of pressure through failure of the pressure regulator. At the end of each pneumatic section, remote from the gas supply, a cable pressure gauge with signalling contacts is fitted.

If the length of the cable is too great to be fed from one end only (i.e. more than about 4

* Abstract. Institution of Electrical Engineers, London. April 29th.

† British Insulated Callender's Cables, Ltd.

miles) yet not long enough to justify the complication of gas-sectionalising joints (i.e. less than about 7 miles), it is operated as a single pneumatic section, but provision is made for a gas feed at each end. In such cases, in the initial gassing of the system, gas is fed in at one end only while the gauge at the other end is observed. The second gas feed is not brought into operation until gas continuity has been fully established.

The arrangements described above are flexible and can be modified to suit local conditions. In single-core installations, the gas feed is usually at the sealing ends and several ends can be supplied from the same source.

After several years of experience with the impregnated-pressure-cable system, it is profitable to survey the results to see whether any weaknesses which have appeared can be overcome.

Electrical Faults

As can be seen from Table I, the Burford single-core and three-core cables were the first to be installed which were long enough to require straight joints. In the design of these joints, which was finalised prior to the introduction of impulse tests into the Central Electricity Board's specification, pre-shaped factory-made paper-roll stress cones were used for stress control.

The cables are connected between long lengths of overhead line, and several failures attributed to switching surges occurred, three in the single-core cable (1944 and 1948) and one in the three-core (1948). The joints which failed (and also three additional single-core joints which it was convenient to deal with) were remade with hand-applied pre-impregnated-paper tapes.

The 1944 incident was the origin of the modern jointing procedure which has been used on all subsequent installations, and no other failures of any kind have occurred.

In 1951, a sealing-end external flashover occurred in one phase of the 132kV 0·4 square inch cable installed at Hams Hall in 1948, and resulted in fracture of the porcelain. Although the porcelain was of the semi-conducting-glaze type[5] the flashover was attributed to severe pollution. The sealing end was remade on the original cable and put back into service. No other incidents have occurred, but a number of semi-conducting-glaze porcelains which are installed are under periodic superficial examination in order to collect data on their life characteristics.

Only one cable failure has occurred, and the incident is of considerable interest. The Stoke-Longton three-core 33kV 0·4 square inch cable installed in 1949 operated satisfactorily until 1952, when it was taken out of commission for the construction of a loop into a new substation. After completion of the modifications, the system was repressurised, but when the routine 66kV d.c. fifteen-minute test was applied, failure occurred on two phases. The faults were located to a length of cable between joints where it passed through an area where there had been repeated incidents of ground subsidence ; buildings had been damaged, water mains fractured, &c.

On excavation three serious kinks, which appeared to have been caused by a considerable compressive force, were found in the cable. The cable servings were intact, but the reinforcement was seriously damaged ; the lead sheath was badly deformed, although still gas-tight. The degree of damage suffered by the cores varied in the three cases, but in general the dielectric papers were severely torn, something less than half of the original wall thickness remaining intact. Apart from the tearing, the papers were in perfectly good condition, no sign whatever of electrical deterioration being present. The conductors were found to be sharply bent through a considerable angle. Had the distortion been uniform, it would have corresponded approximately to bending the cable around a radius six times the diameter over the lead sheath.

The exact mechanism of the failure is obscure. The absence of any sign of electrical deterioration makes it appear unlikely that the cable had been subject to alternating voltage whilst in its damaged condition. On the other hand, no new subsidence was known to have occurred during the three weeks while the system was undergoing modification. One theory put forward was that the cable may have been under mechanical stress and that the removal and reapplication of the gas pressure caused a sudden deformation. Against this, pilot cables in the same trench were also similarly distorted. Whatever the mechanism, however, it is clear that the failure was due to abnormal subsidence conditions.

Apart from the incidents described above, no electrical faults have occurred. The electrical performance of the cable can therefore be said to be completely satisfactory.

Gas Leakage

A number of cases of gas leakage have been reported and these have arisen from a variety of causes. The majority of leaks have been at a rate of about 1 litre of gas per minute at n.t.p., and the rate of 2 litres per minute has rarely been exceeded. A high proportion of leaks have been not in the cable itself but in the gas-feeding equipment (i.e. in pipework connections, valves, &c.). Leakages from accessories through plumbs or washers, &c., have been seven in number.

Leakages through the cable sheath have numbered ten in all.

In aluminium-sheathed cables there has been only one such case, and this was found to be due to a minute ferrous inclusion. This had apparently been introduced during the handling of the aluminium billet from which the tube was extruded. The tube was gas-tight when given preliminary testing, but the inclusion, caused a very small crack later, probably as the tube was being drawn down over the cable cores, but possibly during bending. The leak was found during the installation of the cable.

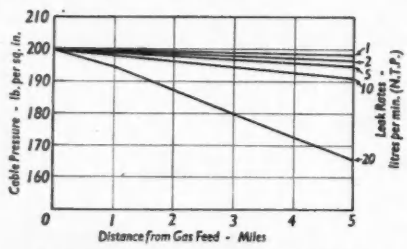


Fig. 1—Variation of Pressure with Leak Rate

In lead-sheathed cables, sheath faults have been of three types.

(*a*) The first of these has been associated with disturbance of the longitudinal reinforcing tapes.

The Burford three-core cable developed a small leak after several years in service. No serious attempt was made to find it until recently, when it was located to a point where a longitudinal tape had been applied with a slight twist during cable manufacture. During the course of time the twist had become accentuated, perhaps through gas pressure or perhaps through thermal movement, and the sheath had ultimately been penetrated.

Four cases have occurred in which the longitudinal tapes, instead of lying smoothly around the cable, have become rucked. In one example a gas leak through sheath penetration did not appear until the cable had been in service for three years ; in the others the faults developed almost immediately. The way in which this rucking occurred is not fully understood, despite considerable experimental effort. It is, of course, impossible to apply the tapes—which are at an angle of only 20 deg. to the cable axis—so that there is absolutely no slack, and it appears that by some unusual combination (during handling and laying) of twisting coupled with "pushing back," the slack can become accumulated at one point. The external resistance of the circumferential reinforcing tapes causes the accumulated length of longitudinal tape to be compressed into a series of small folds, and these are then forced into the lead sheath. All attempts to simulate the effect in the laboratory have been unsuccessful, as the rucking artificially produced has been achieved only by a degree of twisting and pushing which is quite impossible in practice. Although the mechanism is not truly understood, the likelihood of its happening again, now that these few cases have come to light, is reduced by very careful control of the conditions during cable laying, so that, for example, any twisting which may occur is in such a direction as to tighten, and not loosen, the longitudinal tapes.

(*b*) The position in the cast plumb at the end of a joint where the reinforcement is terminated has been the source of leaks in few cases.

The original method of finishing off the reinforcement was such that cable movements during operation could cause the ends of the tapes to be pulled in towards the lead sheath, causing cracking. The design and the plumbing technique have now been modified so that this cannot happen.

(*c*) Only in four cases have leaks in lead-sheathed cables been caused by extrusion defects, three of them due to oxide inclusions. Three of the four defects were in very early cables in which the sheath was extruded by presses not fulfilling the requirements given in Section 2.3 and the other was found before the cable installation was completed.

The Significance of Gas Leaks.—In all high-performance cables depending on an internal pressure, whether gaseous or fluid, the possibility of leakage must be accepted. The smaller the leak in a gas-pressure-cable system, the more difficult and costly it is to find ; on the other hand, the need for finding it becomes less.

In the impregnated pressure cable the pneumatic system is arranged so that the cable is automatically fed with gas if a leak occurs, and a signal is given as soon as the pressure in the permanently-connected supply cylinders begins to fall appreciably. If this signal should be disregarded, the cylinder pressure continues to fall whilst the cable is still maintained under full pressure. Then, when the cylinders are almost exhausted and the cable pressure begins to fall, a further signal is given. It is not until this happens that emergency action is required.

The impregnated pressure cable, with its gas channel pipe, has a low resistance to longitudinal gas flow, and even a fairly large gas leak, therefore, causes very little pressure drop provided that the gas-feeding point is not too far distant.

Fig. 1 shows the pressure which exists in an installation 5 miles long, having the standard 0·25in diameter gas channel pipe, fed with nitrogen at one end and with leakage rates of 1, 2, 5, 10 and 20 litres per minute (at n.t.p.) at the other. It will be seen that conditions are safe even at the highest rate of leakage, which is far in excess of any which have been experienced under actual working conditions.

A nitrogen cylinder containing 28 litres of gas at an initial pressure of 1900 lb per square inch has a useful life under leakage conditions as shown in Fig. 2. In this curve, the time is that for the cylinder pressure to fall to 450 lb per square inch, which is the lowest recommended. Generally, two or more cylinders are used, so that the time is increased in proportion.

The two curves, considered together, show that leaks below about 1 litre per minute have no significance and are best ignored. The occasional cylinder replacement is inexpensive and requires no skill.

Gas Leak Location

When a leak must be found, several methods are available. In the methods described the simple case of leaks from pipework, &c., is omitted. Such leaks are very easily found with soap and water, and a repair can generally be effected without depressurising. When the leak is on the cable side of the control valves a simple freezing technique, recently perfected, is used. The affected pipe, or the end of the associated cable, is fed with carbon dioxide whilst a freezing box containing liquid oxygen is placed around it. The carbon dioxide solidifies and holds the pressure while the repair is being made.

Oxygen Method.—After ensuring that the installation pressure condition is stable—i.e. that the only gas movement within the cable is the flow to the leak point—the nitrogen supply is replaced by dry air. Pressure in the cable is maintained rigidly constant during the changeover and throughout the time subsequently needed to feed in air. The insertion of air is continued until it would reach the leak, even if this were at the far end of the installation. Thus,

as the nitrogen is lost out of the leak point, it is replaced by air until all the nitrogen up to the leak point is so replaced. Further supply of air is simply lost out of the leak.

The air supply is then removed and a nitrogen supply placed on the remote end at a pressure slightly in excess of the existing cable pressure. The air is expelled at a known constant rate through an oxygen recorder, and, from a knowledge of the volumes of the system, the length of the air column is determined, and hence the position of the leak. To improve accuracy, if necessary, the operations can be repeated working from the opposite direction. The method has an accuracy within ±1 per cent and can be carried out with the cable in service, but it is slow, particularly with small leaks.

On single-core cables a direct location is obtained, but on three-core cables the arrangement of gas channel pipe and breeches piece permits a first location only to a joint and its associated cable length. If the leak is at the joint, this is sufficient, but if it is in the cable, then the process must be repeated on the particular length of cable itself and not on the gas channel pipe.

This is satisfactory on lengths of cables between joints, but could not be done without loss of accuracy on a mile or more because of the excessive mixture of air and nitrogen which would occur in the large free volume of the cable system. This is where the breeches piece, by splitting up the system into short sections, is of value.

Differential Gas Flow.—The principle is to determine the direction of gas flow, either in the cable or in the gas channel pipe, at various points along the cable route. Since the flow is always towards the leak, its position can be determined with an ultimate accuracy of a few yards.

A heater coil is applied round the cable (or the gas channel pipe at surface box positions) and, equidistant on each side of the heater, thermo-couples or resistance coils are affixed. Heat will then be transferred by the gas flow to the thermo-couple or coil on the side towards the leak.

When the test is made on the gas pipe the direction of flow can be determined with leaks as low as 0·1 litre per minute (n.t.p.), but on a large cable itself the sensitivity is usually not better than 2 litres per minute.

Mechanical Automatic Devices.—In one installation pressure-sensitive relays were included in every joint in conjunction with integral pilot wires, so that any gas flow in the joint caused a signal to be given. The method has, however, been abandoned as uneconomic and unnecessary.

Tracer Gas: Halogen Group.—A dilute mixture of a gas containing a halogen (e.g. Arcton, sulphur hexafluoride, &c.) is fed into the cable and its progress followed with a halogen detector. The method can be used in the same way as the oxygen method, but it is often possible to detect the halogen at ground level at the leak position. When this is so the method is ideal, because the gas can be fed in in excess of the leak rate, the cable can remain in service throughout, and the accuracy is high. The technique is still being developed, but it has already been eminently successful in some cases.

Tracer Gas: Radioactive Isotopes.—The tracer gas method, at least so far as the impregnated pressure cable is concerned, is still in the early stages of development, and, in view of the probable refinement of existing methods, it is doubtful whether it will find extensive use.

The selection of the most suitable tracer presents difficulties. Apart from the necessity of its possessing the correct emission characteristics, it is important that its life shall be sufficiently long for it to remain active even in the case of a small leak when a long time elapses between the insertion of the tracer and its emergence from the leak position, but it must not be so long that it persists in the cable and interferes with any subsequent detection operation. Also, in order that it can be detected from above ground it must have a very low water solubility so that the active material is not prevented from reaching the surface.

A number of materials have been suggested, e.g. carbon monoxide (carbon 14), ethyl and methyl bromides (bromine 82), radon and xenon; all of these have disadvantages.

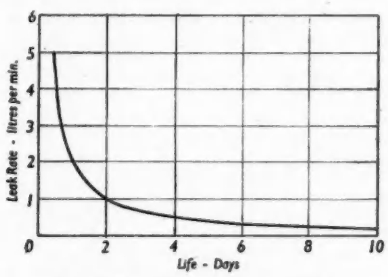
It has been found that selenium 75 combined in the form of dimethyl selenide, is suitable in all respects. The half-life is 127 days, the water solubility of the compound is such that it cannot be washed away by heavy rain or otherwise prevented from reaching the surface, and it is a sufficiently powerful γ-ray emitter to permit its passage through the cable to be detected from outside the sheath. Further, it is relatively easy and cheap to manufacture.

Compound Movement

Movement of the impregnating compound into positions where it restricts gas flow has occurred in certain cases. The two reasons for this are described below, the first being relatively infrequent.

Movement by Gravity.—In both single and three-core cables the gas pressure ultimately reaches the dielectric through the annular space between the core, or cores, and the sheath. If a cable is installed on a severe gradient, and particularly when it is operated at full working temperatures and the compound viscosity is lowest, the compound tends to move downwards and may be in sufficient quantity to fill the annular space at the lowest point.

The only case where actual gravity blockage has been known to be present is in the single-core 66kV, 0·75 square inch cables installed at Battersea in 1940. These cables have been heavily loaded and have a vertical rise of about 80ft at each end, and the annulus became filled with compound early in their life. No action was required until 1952, when the sealing ends at one end were modernised. The excess compound was then very easily cleared by forcing out



(Pressure loss, 1900–450 lb per square inch)

Fig. 2—Life of a Cylinder

a small quantity of compound under gas pressure.

Movement by Frothing.—In an installation which has been pressurised, nitrogen at high pressure permeates every part of the system within the cable sheath, joint sleeves, &c. Nitrogen is soluble in cable-impregnating compound, which therefore eventually becomes saturated with gas in solution. The solubility is such that one volume of compound takes up approximately one-tenth of a volume of gas, independent of pressure.

The gas is dissolved at 200 lb per square inch, and so, if the cable pressure is reduced to atmospheric, a considerable volume of gas (i.e. about 1·5 times the volume of compound) is released from the compound to restore equilibrium.

A sudden evolution of free nitrogen within the impregnant results in the formation of bubbles, which grow as the outside pressure is reduced. When they reach a free surface, they do not immediately burst, but persist in the form of froth. Hence, when an impregnated pressure cable is depressurised rapidly, froth is introduced into the clearance space between the cores and the sheath and travels with the general flow of gas which is leaving the installation. Froth is thus carried into joint sleeves, where the bubbles tend to enlarge and burst, the compound then draining to the bottom of the joint.

When frothing is severe, however, the joint sleeves may be wholly filled with froth, which then gets carried into the gas channel pipe through which the cable is being depressurised. If an installation is left in the depressurised state, any resulting compound film within the gas channel pipe slowly drains to the lowest point and such points may become completely filled with compound. The result is that repressurising can proceed only slowly, dependent on the rate at which the compound blockage is cleared by the high pressure of the inflowing gas.

In a number of cases a gas flow restriction has been created by this mechanism. Although this may appear to be a cause for anxiety, its only practical result is the inconvenience of a slower regassing operation.

Data has been compiled from the records of installations comprising fifty separate pneumatic sections. On these, depressurising has been carried out as follows :—

To permit modifications	10
To repair accidental damage	1
For rectification (e.g. leaks)	8

From these records it appears that full repressurising has, on the average, taken two and a half times as long as the original pressurising. In considering this it must be borne in mind that usually there was no attempt to carry out the operation in the minimum possible time, either initially or on repressurising. Also, repressurising is only a part of the whole operation of modification, repair, &c. If a case of emergency arises there are various expedients by which the operation can be accelerated.

To reduce frothing to a minimum, depressurising must be carried out with care and at a slow controlled rate of leakage—never more than 2 litres per minute—although this rate may be applied at a number of points simultaneously.

It might be considered that compound blockages, coupled with gas leaks, could create a dangerous condition. This has never arisen and is not to be expected, since there is always more than one path along which gas can flow. As an example, consider a three-core cable with a breeches piece in each joint. The normal gas path in each length of cable between joints is through the gas channel pipe, into the joint, along the annular space and thence into the dielectric. Let it be supposed that the annular space is blocked at some point along the cable length and that a gas leak then occurs on the side of the blockage remote from the joint from which the cable is normally fed. What would happen under these conditions is that the breeches piece on the leak side would permit gas to flow into the affected cable as soon as its pressure had fallen appreciably. The breeches piece is not intended to be a perfectly gastight seal, since it is bound only loosely on to the cores and leaks readily when there is a pressure difference across it. Also, gas would find its way to supply the leak through the cable cores or fillers.

The prospect of a leak being present without giving an indication through the signalling equipment may therefore be considered extremely remote.

Discussion of the Operational Experience

The above account shows that, electrically, the cable is wholly satisfactory.

Certain pneumatic imperfections have come to light and comparable inconveniences occur in most cable systems. The two which have attracted attention are gas leakage and compound blockage. There is no doubt that improvements can be made, and proposals in this direction are dealt with below. In the meantime the pneumatic system is designed so that any difficulties which might arise under any combination of circumstances are minimised. For example, careful planning makes it possible to decide the best points for gas feeding; how many points should be allowed; how many surface boxes should be provided and where they should be situated; whether the route should be sectionalised; and so on. Also, although it is now generally agreed that small gas leaks are not worth the time and trouble taken to find them, location techniques are steadily improving and good planning also simplifies the problem.

Future Developments

Joints.—Impregnated pressure cable joints take a long time to construct on site. A 33kV straight joint takes fifty hours to complete. This is partly due to the use of hand-applied dielectric and partly to the rather complicated sleeve design now used.

In its electrical performance the joint is highly successful and any proposed modifications would need to be approached with caution. The mechanical arrangement may be simplified. The double-sleeve arrangement in straight joints

was originally designed so that all of the plumbs made during construction could be tested for gas-tightness by evacuating the inter-sleeve space. The test could be made joint by joint during installation work, and trenches could be filled in progressively with a reasonable assurance that the system would be gastight when pressurised. However, certain accessories do not have a double skin and are therefore not tested in this way—i.e. sectionalising joints and sealing ends.

A survey was made of the leaks which have occurred in the two types of accessory, both in initial construction and subsequently. Between 1944 and 1951, 838 double-sleeve and 342 single-sleeve accessories were installed and the analysis of the incidents brought out two points. First, the proportion of leaks in single-sleeve accessories was less than that in double-sleeve accessories. Secondly, the majority of leaks in the latter occurred during 1948 and 1949. On analysis, it was found that this was due mainly to difficulties encountered in satisfactorily completing a large plumb between the outer sleeve, the end gland and the cable sheath. Thus it appears that the complication of the joint by providing a double sleeve to ease leak location did, in fact, increase the number of leaks encountered during construction work.

It has therefore been decided to introduce a single-sleeve straight joint in which a further simplification has been made by replacing the cast plumb by a mechanical seal as used successfully in aluminium-sheathed installations. This type of joint has the advantages that it is quicker and cheaper to make and remake, and that it reduces the number of points where leaks might occur. In addition, the simplifications make it possible to consider bringing out the gas channel pipe at every joint. It is not proposed to install surface boxes every time, but a readily accessible gas channel pipe simplifies gas leak location, and the differential gas flow method can be used with much increased precision and without interfering with the main cable system in any way.

Another interesting possibility is to introduce a pipe towards the bottom of the sleeve. This pipe can be fitted with a valve installed in an accessible position and used during depressurising operations. With this arrangement any compound at the bottom of the joint can be blown out and the risk of compound froth blocking the main gas channel pipe is removed.

Cable.—Some prospective developments, such as the general use of conductor compacting and screening and the employment of thin paper tapes to increase electric strength, are applicable to nearly all types of cable, and it is unnecessary to refer to them in detail here. Whilst such improvements are attractive, particularly for the higher-voltage cables, as a means of increasing operating stresses and reducing size and cost, service performance has fully proved the present electrical designs.

It is only in the pneumatic features that improvements would be justified, especially in relation to the compound migration inconvenience described above.

The compound which tends to cause obstructions must come in part from the cable dielectric itself, and in three-core cables from the fillers as well, in which there is a large quantity of free compound serving no useful electrical purpose. Also, just as in a solid cable, thermal expansion of the compound during heat cycles must also expel compound from the dielectric.

Therefore, under operating conditions, particularly under conditions of severe gradients and degassing and regassing operations, the dielectric becomes less fully impregnated than when it is first manufactured. The effects of this on the electrical characteristics must be considered from the two aspects of alternating current and impulse strength.

Under all conditions to be expected in a.c. operation, the compound movement produces no effect on stability, assessed in the usual way by power factor measurements. This has been adequately demonstrated by numerous type tests, development tests and prolonged stability tests. [Details are given in the paper.]

Compound movement has very little effect on the impulse performance. (This is in line with the observed performance of solid cables.)

Although compound movement has no observable effect under normal or somewhat stringent a.c. tests, changes can be measured at higher stresses.

When the power-factor/stress curve is measured on a new fully impregnated cable, the curve is flat at about 0·0025 up to a stress of 200kV per centimetre, but rises at higher stresses. The stress at which this rise commences, as measured by a power-factor increase of 0·0001, is termed in the present paper "ionisation inception stress." This is a convenient definition, although it is not known whether ionisation in the form of actual gaseous discharge takes place. Further, it is known that cables can operate without failure for very long periods at higher stresses. Nevertheless, it provides a ready means of comparing the results of different tests.

Cables which have been severely aged, e.g., the cable described in Section 6.2.1 (*c*) of the paper, which in addition to 5500 hours on test had been depressurised three times, exhibit an ionisation inception stress of 150kV per centimetre. This and other experiments have shown that, however severe the sequence of operational conditions, there is no further fall in the ionisation inception stress, and it is concluded that cables will be absolutely stable electrically provided the working stress does not exceed 150kV per centimetre for prolonged periods. This value applies to an unscreened conductor and a dielectric of the normal standard type previously described, and it is safely in excess of the maximum conductor stress design used, namely, 100kV per centimetre at 132kV.

The possibility therefore arises of conditioning a cable to its ultimate stable state to improve pneumatic performance without prejudicing service life.

It is found that a stable compound content is attained by draining cables for forty-eight hours at 120 deg. Cent. under vacuum at the end of the normal impregnating process. On testing cables made in this way, the ionisation inception stress is 150kV per centimetre and the value remains constant during prolonged tests.

When "solid" cables were the only type available, it became customary to attempt to estimate their likely service performance by high-voltage a.c. tests on new cable. This was an attempt to assess the probable effect during life of the ionisation which was certain to occur after vacuous spaces had been formed by thermal movement of the impregnant. The tests were justified, since there was no other known means of assessment.

The practice has continued, more in some countries than in others, with the modern types of cable in which ionisation is prevented. The results are unreal and misleading. The cables in service need only to withstand without deterioration the maximum alternating voltage possible on the system, what happens at higher voltages being quite irrelevant.

With the impregnated pressure cable as described, the limiting stress design factor at voltages up to 132kV is the impulse requirement, the test for which gives a reasonable representation of service conditions. At higher voltages, although the impulse condition continues to become progressively less onerous, the maximum electric stress at the conductor cannot be increased in proportion because account must be taken of the possible inception of ionisation at 150kV per centimetre.

This is a pessimistic view for two reasons. First, the beginning of the upward sweep of the power-factor/voltage curve does not necessarily indicate the onset of gaseous ionisation discharge. Secondly, cable failure does not follow even if the operating stress is somewhat above this so-called ionisation inception stress. This has been proved by experiments in which cables have been operated, under heat cycles, at stresses some 10 or 20kV per centimetre higher. Under this condition the power-factor/voltage curve actually flattens, and the ionisation inception stress appears to rise. However, it is sound engineering to arrange that the cable is not operated at above 150kV per centimetre for any prolonged period.

The highest design stress proposed (with normally constructed cable) is 100kV per centimetre at nominal system voltage, or approximately 110kV per centimetre at the probable maximum system voltage. The margin is thus 40kV per centimetre, which is adequate. This margin cannot be translated into a "factor of safety" because, as no changes in conditions take place, the factor is infinite. With screened conductor cable the safe stress can be 110kV per centimetre (or perhaps rather higher). Change in the construction of the paper dielectric such as the use of graded thickness of papers will still further increase this figure.

Conclusions

With approximately 150 feeder miles in service, the impregnated pressure cable has proved to be sound. Its pneumatic performance is capable of improvement and steps in this direction can be expected.

Whilst it is not the purpose of the paper to make comparisons between different systems, it must be kept in mind that no cable system has yet been developed without corresponding difficulties.

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French Engineering News

(By Our French Correspondent)

The Ministry of Public Works has estimated that the damage caused by the recent floods and storms to the port of Dunkerque amounts to at least £1,000,000. Floating docks broke loose and were damaged and much of the electrical installation was also damaged. Some of the operating gear for opening and closing dock gates, &c., has not yet been put back into service. Special credits have been voted for reconstruction work, and a plan has been prepared for the construction of new breakwaters; construction of a new dock is to be accelerated for completion this year.

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An oil storage tank farm has been completed at Dakar for the Sté d'Entreposage d'Hydrocarbures with a capacity of 5000 cubic metres. Oil is brought to the farm in tanker barges from Garoua.

* * *

French tractor manufacturers have organised a competition for the design of a diesel-engined 80 h.p. caterpillar angledozer or scraper, intended for production on a large scale. A jury has been appointed to examine the entries, which will have to be ready by April 1st. Once a tractor has been chosen from the entries, arrangements will be made for building the machine on a large scale, it is stated. Crude oil production in France and the French Union in 1952 amounted to 500,000 tons, against 375,000 tons in 1951. Petrol consumption also increased over the same year. Consumption of aviation spirit increased from 123,700 tons in 1951 to 136,000 tons in 1952, and diesel oil consumption from 1,235,000 tons to 1,245,000 tons.

* * *

The second turbo-alternator set came into operation at the end of February at the hydro-electric power station of Brevieres, in Savoie. This power station is supplied from Tignes reservoir, on the Isere, and was described in our issue of December 21, 1951. When completed it will have three 36MW sets, generating 158 million kilowatt-hours per year.

* * *

Final automobile construction figures for 1952 have now been published. France built 499,609 vehicles, including 370,000 private and touring cars, 127,000 commercial and industrial vehicles and 2109 other types. In 1951 the figures were 445,958 vehicles, of which 313,927 were private and 127,935 industrial or commercial. Automobile production in France has doubled since 1938, and the greatest progress has been made with private cars. In 1952 France exported 108,034 vehicles, against 125,295 in 1951.

Industrial and Labour Notes

The Coal Board's Report

The annual report of the National Coal Board, covering the calendar year 1952, was published last week. It included the annual accounts which revealed a deficit on the year of £8,200,000, which increased the accumulated deficit since vesting day to £14,000,000. Last year's deficit is explained by the fact that the operating profits of collieries, before paying interest, fell from £21,200,000 in 1951 to £5,700,000. Higher proceeds from the sale of coal were not sufficient to meet higher production costs, and the report shows that it cost 56s. 9d. to produce a ton of coal last year, compared with 49s. 2d. in 1951. The Board spent £45,500,000 on capital account last year, compared with £32,000,000 in 1951, and the report notes that of the increase of £13,500,000 about £4,000,000 was due to higher prices of equipment. At the end of the year the capital expenditure authorised by the Board, but not yet incurred, amounted to £119 million, compared with £94,000,000 at the end of 1951. To finance the increasing requirements for capital expenditure and working capital, the Board borrowed £31,400,000 from the Minister of Fuel and Power, of which sum £20,000,000 was funded as representing permanent advances.

The chapter of the report which deals with manpower and productivity records that by the end of last year there were 720,000 men in the industry, which was 22,500 more than at the end of 1951. It is stated that the improvement was attributable rather to smaller wastage than to greater recruitment, although many more youths under eighteen were recruited than in previous years. The number of faceworkers increased by 12,000, or 4·2 per cent over 1951. There was one more working day last year than in 1951, but each miner on the average worked the same number of shifts as in 1951 and produced less coal per shift. Output per man-year in 1952 was 299 tons, which was 4 tons less than in 1951. Output per man-shift at the face fell from 3·17 tons in 1951 to 3·15 tons last year. According to the report, there was less Saturday working last year, compared with 1951, but the attendance rate on the other five days of the week was slightly better. The comment is added, however, that " there is still great room for improvement in attendance." In another section of the report it is noted that last year nearly twice as much coal was lost as in 1951 from stoppages of work and " go-slow " movements, some of which were associated with negotiations on wages of mineworkers and under-officials.

The report records that in April, 1952, responsibility for opencast working was transferred from the Ministry of Fuel and Power to the National Coal Board, although the Government remained responsible for the requisitioning of land and for completing its restoration. The average cost of producing opencast coal last year was 49s. 11d. a ton, and in the nine months, April to December, a loss of £993,050, or 2s. 1½d. a ton, was incurred. The Board says that virtually the whole of this loss was due to the expense of stocking opencast coal during the summer and autumn, when demand fell. The amount of land still requisitioned at the end of 1952 was 25,000 acres, and the Board estimates that with this acreage at least 10,000,000 tons of coal can be won each year by opencast methods.

Trade with the U.S.A.

On Thursday of last week, the British Engineers' Association held a luncheon in London, at which the principal guest was Mr. Lincoln Gordon, Minister for Economic Affairs in the United States Embassy. The president of the Association, Mr. D. D. Walker, was in the chair.

In the course of a speech following the luncheon, Mr. Lincoln Gordon said that United States imports from the rest of the world were now running at the rate of 11 billion dollars a year, which in money terms was five times as much as before the war. A good part of that, of course, was due to inflation, but, ignoring values and thinking in terms of volume, the U.S.A., Mr. Gordon stated, was importing about twice as much as before the war. He went on to say that last year the U.S.A. bought more than twice as much by value from the United Kingdom as it did in 1948, and by volume 85 per cent more. Direct exports from the United Kingdom to the U.S.A. had increased in every year since the war, except one. Last year, Mr. Gordon continued, they reached the record amount of 400 million dollars' worth, and in April of this year United Kingdom exports to the U.S.A. were valued at about 38,000,000 dollars, a record exceeded in only two months previously.

Mr. Gordon went on to say that this trade was essential to the well-being of both countries. There were many commodities and products in the sterling area which America needed and imported, and similarly there were many commodities in America which the United Kingdom needed and must import for the proper working of its economy. But, Mr. Gordon observed, the United States was not the only place to earn American dollars. Other areas were selling the U.S.A. increasing quantities of raw materials for its own expanding economy, and those countries offered increasing possibilities of dollar earnings through triangular trade. Such markets, he suggested, opened great possibilities to the British engineering industries.

Trading Opportunities in Central America

The Federation of British Industries has issued a booklet which has been prepared by Mr. A. C. McKechnie, head of the F.B.I. Latin-American department. Mr. McKechnie was joint secretary to the British Trade Mission which went last year to the Caribbean. When that mission had completed its tour, Mr. McKechnie visited Panama, Honduras, El Salvador and Guatemala, and this booklet sets out his suggestions as to how Britain's share of trade with those republics of Central America can be increased. The booklet explains that, in 1951, goods imported by the six Central American republics were valued at approximately 335 million dollars, of which the U.S.A. supplied 68 per cent and the United Kingdom only about 4 per cent. Mr. McKechnie stresses the need for quick deliveries and firm prices in any consideration of trade with Central America. He says also that sales efforts based on catalogues and literature alone are unlikely to be productive. A matter of the first importance is that examples of equipment offered for sale should be available for demonstration on the spot, and that spare parts and after-sales service should be assured. Another point to which Mr. McKechnie directs attention is that maintenance and service manuals and all other literature should be in Spanish.

Industry in the North

Last week, the Parliamentary Secretary to the Board of Trade, Mr. Henry Strauss, Q.C., received a deputation from the Northern Industrial Group and the North-East Development Association. The deputation was headed by Lord Ridley, who emphasised that West Durham, and particularly North-West Durham, was bound to be faced with a problem in future years owing to the decline in coal mining. The deputation was anxious to have from the Board of Trade an assurance that it recognised the situation and had sufficient information about the decline of mining to enable it to take measures to deal with the problems arising.

Mr. Strauss said that the Board of Trade had long been aware of the future problem in West Durham and welcomed the detailed study which had been made available by the enterprise of the Northern Industrial Group. The position was being reviewed by the National Coal Board, which was discussing the decline of coal mining within the industry. It could not, however, yet be foreseen where, when and to what extent a problem would actually arise. Mr. Strauss assured the deputation that the Board of Trade and other Government departments concerned were watching these developments closely, and said that the provisions of the Distribution of Industry Act would be used as necessary. He hoped that the Northern Industrial Group itself would continue its researches and consider whether some of the existing industries of the North-East might not undertake some expansion, perhaps into new lines of production.

Engineering Wages

As these notes go to press the Confederation of Shipbuilding and Engineering Unions is giving further consideration to the formulation of a claim for a 15 per cent increase in the wages of shipbuilding and engineering workers. The matter was first mooted by the Confederation at the end of last month, and it was then recommended that the executives of the thirty-eight affiliated unions should consider it. Since then the proposal has been discussed at the annual conferences of the Amalgamated Engineering Union and the Electrical Trades Union, delegates at both of which have expressed support for the formulation of a claim.

In the past week the view of engineering employers on the matter has been expressed by Mr. A. W. Grant, chairman of the Engineering and Allied Employers West of England Association, and by Mr. H. A. Smith, president of the Engineering and Allied Employers South Wales Association. In a speech on Monday last, Mr. Smith said that the unions should face the fact that the engineering industry was not on the crest of a wave of prosperity, and that fresh wage demands could not be justified on that score. Engineering firms were at present engaged in a desperate uphill struggle to improve exports, and competition from abroad was fiercer than had ever been met before. If, Mr. Smith continued, the industry was to survive in the export battle, costs must be stabilised and indeed reduced as swiftly as possible. To raise costs now by increasing wages, he added, was to ask for trouble. Such a move would prove fatal to many individual firms and, ultimately, fatal to the whole of Britain's tightly-strung economy.

Volume of Import and Export Trade

In the current issue of the *Board of Trade Journal*, some particulars are given of the volume of imports and exports during the first quarter of this year. The figures show that the volume of total imports at 106 (1950=100) was 6 per cent greater than in the last quarter of 1952, and about 3 per cent above the level for the whole of last year. The volume of exports at 94 was about 2 per cent below the figure for the final quarter of last year, which was slightly above that for the whole of 1952. Among exports, the volume index for manufactured goods, at 93, was slightly lower in the first quarter of this year than in the final quarter of 1952. The index for textiles and clothing was unchanged at 81 ; the volume of exports of metals and engineering products fell from 95 to 93, while the index for " other manufactures " rose by 1 point to 104, partly on account of a further rise in the group which includes refined petroleum.

Subject Index to Patent Specifications

On account of wartime difficulties, the printing of subject indexes to British patent specifications since 1939 (No. 500,001 onwards) has fallen seriously into arrears. Good progress has been made in reducing those arrears, but it is understood that their complete elimination is unlikely to be achieved in less than two years.

H.M. Patent Office has given permission to Aslib (Association of Special Libraries and Information Bureaux) to prepare 35mm microfilm copies of the " Press Mark Index " compiled by the Patent Office, and to make them generally available. The " Press Mark Index," which will be in most cases the only subject index available in respect of 1939–1953, is a cumulative list over fourteen years of the 271 patent classes, showing the numbers of the patents in each and their allocation to sub-classes.

The microfilm copies of the index are now available, price ten guineas, from Aslib, 4, Palace Gate, London, W.8.

Notes and Memoranda

Air and Water

WORLD SHIP SOCIETY.—We are informed by the World Ship Society, 110, Fenchurch Street, London, E.C.3, which has as one of its principal objects the compilation of a central record of shipping information relating to ships built since 1815, that there is now sufficient information on record to answer inquiries concerning merchant ships of all nations from 1919 to the present day.

LLOYD'S NEW BUILDING.—On Saturday of last week Lady Garrett, the wife of the chairman of Lloyd's Register of Shipping, laid the foundation stone of Lloyd's new printing house and research laboratory which is to be built at Crawley. When complete the printing machinery will be removed from Southwark, where the existing building is no longer adequate to meet the growing demands.

CHAMBER OF SHIPPING.—At the annual meeting of the Deep Sea Tramp Section of the Chamber of Shipping of the United Kingdom, held on Wednesday of last week, the reasons behind the decline of the tramp fleets were reviewed and the greatest single factor was stated to be the impossibility of setting aside sufficient funds for replacement due to high taxation. During the meeting Mr. J. C. Denholm, the vice-president of the Chamber of Shipping, was elected to succeed Mr. R. D. Ropner, who had completed his two-year term of office as chairman of the section. Mr. L. G. Dann was appointed vice-chairman.

THE "BRITANNIA" AIR LINER.—Three new versions of the Bristol "Britannia" air liner are to be offered for world sale. Designated the "Mk. 200," "250" and "300," they are respectively a freight transport, a mixed freight and passenger aircraft and a passenger air liner. The "Mk. 100," which will first enter service in the livery of B.O.A.C., has a gross weight of 140,000 lb and is powered with Bristol "Proteus" 705 turbo-props of 3780 equivalent horsepower. It has a volumetric payload of 25,000 lb and can carry this load over a still air range of 3650 st. ml. The ultimate payload range is 5700 st. ml. The new "Britannias" have a fuselage 10ft 3in longer than the "Mk. 100," and the gross weight has been increased to 155,000 lb. They will be powered with "Proteus 750" turbo-props of 4150 e.h.p. and it is intended that they shall be available for delivery in 1956/57. The payload of the "Mk. 100" represents slightly below 18 per cent of the gross weight of the aircraft. In the "Mk. 300" the payload is nearly 19½ per cent of the gross weight. The greater power and improved economy of the "Proteus 750" engine make it possible to carry this heavier load not only at a higher maximum cruising speed, (389 m.p.h.) but over a greater range, despite the fact that the fuel capacity of the new "Britannias" is the same as that of the "Mk. 100."

Miscellanea

A HUNGARIAN CHEMICAL PLANT.—A large chemical plant is being built in north-east Hungary, in the region of the Tiszalök power project, which will process natural gas piped into Hungary from Rumania. It is stated that the pipeline will be laid by a Hungarian-Rumanian company but the Hungarian chemical plant, foundations for which were laid last June, is being built by Hungary alone. Power will be supplied by the Tiszalök project and the large quantities of water required will come from the reserves made available by the new Tisza barrage. Preparatory construction work is going on this year and it will not be until 1955 that the main construction begins to take shape.

CATHODIC PROTECTION.—We are informed that the firms of F. A. Hughes and Co., Ltd., and the Westinghouse Brake and Signal Company, Ltd., are collaborating and pooling their respective experience of cathodic corrosion prevention with the object of offering their combined techniques in a practical and comprehensive form. The new service covers the supply of "Guardion" and "Westalite" cathodic protection equipment and offers full consultative and design facilities. This method of corrosion prevention is applicable to all forms of buried or water-immersed metallic structures and full particulars can be obtained from F. A. Hughes and Co., Ltd., Cathodic Protection Division, Bath House, 82, Piccadilly, W.1.

A SMALL CHAIN-GRATE STOKER.—A few years ago a chain-grate stoker small enough to fit the restricted flue spaces of Lancashire and Economic boilers was introduced by Edwin Danks and Co. (Oldbury), Ltd. A new model of this design of stoker, which is known as the "Minor," is now being manufactured in a standard width of 16in and two lengths. It is intended for firing sectional design boilers as used for industrial space heating systems, and with capacities from 750,000 to 2,500,000 B.Th.U. per hour. This stoker is built up on a rigid mild steel chassis and a single motor is used to drive both the grate and the fan. Its chain of special cast iron links is designed to give fine air spacing with even distribution, and the links are self clearing.

CAPPER PASS AWARDS.—The Capper Pass awards adjudicating committee, on behalf of the councils of the Institution of Mining and Metallurgy and the Institute of Metals, has made the following awards for papers published in 1952 in the *Transactions of the Institution of Mining and Metallurgy* and the *Journal of the Institute of Metals*:—£50 to Mr. Edwin Davis and Mr. S. G. Temple, for their paper on "Batch and Continuous Annealing of Copper and Copper Alloys"; £50 to Mr. C. P. Paton for his paper on "Batch Thermal Treatment of Light Alloys"; £50 to Dr. E. C. Ellwood and Mr. T. A. Henderson for their paper on "Some Exploratory Experiments on the Formation and Control of Magnetite During Copper Smelting Operations"; £50 to Mr. P. M. J. Gray for his paper on "The Production of Pure Cerium Metal by Electrolytic and Thermal Reduction Processes"; and £25 to Mr. E. A. Hontoir for his paper on "Determination of Sulphur in Iron Pyrites." The Capper Pass awards, which are made annually from a sum of £200 placed each year at the disposal of the councils of the Institution of Mining and Metallurgy and of the Institute of Metals, by the directors of Capper Pass and Son, Ltd., Bristol, are intended to encourage the publication of papers on processes and plant used in extraction metallurgy and on the subject of assaying, and of papers on processes and plant used in all branches of the non-ferrous metal industry.

THE BOILER AVAILABILITY COMMITTEE.—The Boiler Availability Committee, which was formed early in the second world war, with the object of reducing the effects of fouling and corrosion of the external heating surfaces in large water-tube boilers, has recently published four reports based on its field work and laboratory investigations. The first report is "A Summary of Published Papers"; the second is "The Second Interim Report on External Deposits and Corrosion in Boiler Plant, 1946–51"; the third is a "Bibliography of Papers Relating to the External Fouling and Corrosion of Boiler Plant, 1940–51"; the fourth is the Bruton Investigation Group Report on the "Relationship Between the Chlorine Content of the Coal Burned and the Availability of a Stoker-Fired Boiler." The address of the Boiler Availability Committee is 8, Waterloo Place, Pall Mall, London, S.W.1.

POSITIONING JACKS FOR PLANT ALIGNMENT.—Particulars have been received from Tangyes, Ltd., Cornwall Works, Smethwick, Birmingham, of a new hydraulic jacking equipment specially designed to assist in the positioning and alignment of heavy machinery when it is being installed. This equipment consists of a number of small hydraulic jacking units each having a closed height of from 1⅛in to 2⅛in, depending upon their capacity. The jacking units are coupled through flexible piping to a control manifold to which fluid is supplied by high pressure, hand-operated pumps. Owing to their very limited height, the jacks can be inserted in a small clearance below a machine and raised and lowered as required from a central point. The number of jacks used depends upon the weight and size of the machine involved, and if required they can also be used to effect horizontal movements. Once a machine is accurately aligned and bolted down on permanent packings the jacks can be easily removed.

A VIBRATORY SOIL COMPACTOR.—We are informed that ACROW (Engineers), Ltd., South Wharf, London, W.2, is now the distributor in this country for the "Vibro-Verken" soil compactor, a machine of Swedish origin. The compactor has a solid vibrating base-plate, which is in direct contact with the soil. The vibrator element, which is hinged to the base-plate, comprises two eccentrics which rotate synchronously in opposite directions, so as to produce directed vibratory motion. The combined centrifugal force of the eccentrics is about 9000 lb and the frequency of the vibration is 950 v.p.m. The vibrator element can be turned by a ball crank fitted on the steering handle, causing the resulting directed force of the eccentrics to incline with respect to the vertical plane, so that the compactor can move forwards or backwards, at a greater or lower speed up to 19–26ft per minute on horizontal ground. The compactor is driven by a diesel engine rated at about 10 h.p., which is mounted on an elastically supported base-plate. The total weight of the machine is about 3000 lb.

Launches and Trial Trips

GERALD LD, cargo liner; built by the Ateliers et Chantiers de la Loire, for Dreyfus and Co.; length between perpendiculars 452ft 9in, breadth moulded 60ft 1in, depth to shelter deck 37ft 10in, load draught 25ft 8in, deadweight 9350 tons; designed speed 14·75 knots; five holds, fourteen derricks and two cranes; electrical auxiliaries; Sulzer two-stroke diesel engine, "8 SD 72," 5250 b.h.p. at 125 r.p.m., three 275kW diesel-driven generators. Trial, April.

IRAOUADDY, cargo liner; built by the Forges et Chantiers de la Mediterranée for the Messageries Maritimes; length between perpendiculars 445ft 7in, breadth moulded 60ft 8in, depth to shelter deck 38ft 11in, load draught 26ft, deadweight 8300 tons; five holds, fifteen derricks, including one of 60-ton capacity; two Sulzer diesel engines, each 4200 b.h.p. at 125 r.p.m., six cylinders, 720mm diameter by 1250mm stroke, three 250kW diesel-driven generators. Trial, April.

RUTENFJELL, cargo ship; built by John Crown and Sons, Ltd., for Olsen and Ugelstad, Oslo; length between perpendiculars 250ft, breadth moulded 42ft 6in, depth moulded to upper deck 26ft, deadweight 2750 tons on 18ft 3in draught; two sets of Clark-Sulzer diesel engines. Launch, May 12th.

BLANDFORD, oil tanker; built by Harland and Wolff, Ltd., Govan, for the Blandford Shipping Company, Ltd.; length between perpendiculars 531ft, breadth moulded 74ft, depth moulded 38ft 3in, deadweight 18,500 tons; twenty-seven cargo oil tanks, two pump-rooms; Harland-B. and W. two-cycle, opposed piston engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 113 r.p.m.; two cylindrical, multi-tubular boilers; two 75kW steam-driven and one 75kW diesel-driven generators. Trial, May 14th.

CYMRIC, refrigerated cargo liner; built by Harland and Wolff, Ltd., Belfast, for Shaw Savill and Albion Company, Ltd.; length between perpendiculars 481ft, breadth moulded 69ft, depth moulded to shelter deck 41ft 6in, gross tonnage 10,800; eight water-tight bulkheads, three complete steel decks, six main holds, MacGregor steel hatch covers, one 50-ton, one 25-ton, four 12-ton, twelve 7-ton and six 5-ton derricks; two single-acting, two-stroke, Harland and Wolff opposed piston diesel engines, cylinders 750mm diameter by 2000mm combined stroke; two Clarkson boilers; four 320kW diesel-driven generators. Trial, May 15th.

PONT-AVEN, cargo ship; built by the Ateliers et Chantiers de Bretagne (Nantes), for the Union Industrielle Maritime; length between perpendiculars 249ft 4in, breadth moulded 39ft 5in, depth to shelter deck 23ft, load draught 14ft 7in, deadweight 1700 tons; four holds, MacGregor single-pull hatch covers; M.A.N. single-acting, four-stroke diesel engine, eight cylinders, 460mm diameter by 660mm stroke, 2000 b.h.p. at 250 r.p.m., trial speed 13 knots. Trial, May.

ANTIFER, coaster; built by Société des Chantiers et Ateliers de Saint-Nazaire-Penhoet for Cie Normande de Navigation à Vapeur (Le Hâvre); length between perpendiculars 239ft 6in, breadth moulded 41ft, depth to main deck 21ft 6in, load draught 19ft, deadweight 2800 tons, service speed 10·8 knots; Christiansen Meyer double compound reciprocating steam engine, 380mm by 810mm by 810mm stroke, 1200 i.h.p. at 120 r.p.m., two oil-fired cylindrical boilers. Trial, May.

CALTEX CANBERRA, oil tanker; built by the Furness Shipbuilding Company, Ltd., for the Overseas Tankship (U.K.), Ltd.; length between perpendiculars 515ft, breadth moulded 70ft, depth moulded 39ft 9in, deadweight 17,400 tons, summer draught 30ft 4½in; twenty-seven cargo oil tanks, one pump-room, three 625 tons per hour turbo-driven centrifugal pumps, three 200 tons per hour Duplex stripping pumps, two 300kW turbo-generators, one 75kW diesel-driven generator, two 50kW motor generators; one set of Richardsons Westgarth double-reduction steam turbines, 7300 s.h.p. at propeller revolutions of 100 r.p.m., maximum power 8200 s.h.p.; two Foster Wheeler "D" boilers provide steam at 450 lb per square inch. Trial, May.

Personal and Business

MR. R. H. G. LEE has been appointed a director of Automatic Telephone and Electric Company, Ltd.

VICKERS-ARMSTRONGS, Ltd., states that Mr. Jeffrey Quill has been appointed sales and liaison manager for Supermarine Works.

HERBERT MORRIS, Ltd., Loughborough, announces that Mr. H. Flavell, chief buyer, has been elected a director of the company.

MR. WALTER NEWMAN, chief designer of Salford Electrical Instruments, Ltd., has retired after forty-five years in the company's service.

PICKERINGS, Ltd., Stockton-on-Tees, states that its Scottish area office has been moved to 66–70, McCulloch Street, Glasgow, S.1 (telephone, Glasgow South 1884).

MR. A. W. DANIELS, M.I.Mech.E., has resigned from the board of B.V.C. Industrial Constructions, Ltd., and will end his association with the company on May 31st.

MR. JOHN ALCOCK, chairman and managing director of the Hunslet Engine Company, Ltd., Leeds, has been elected president of the Locomotive Manufacturers' Association.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND announces the appointment of Mr. J. C. Robertson as honorary treasurer, in succession to Mr. G. J. Innes, who has resigned.

BROWN, LENOX AND CO., Ltd., states that Mr. C. J. Porteous has been appointed London sales manager in charge of its new sales office at 157, Victoria Street, S.W.1 (telephone, Tate Gallery 9191).

MR. R. E. DAWTREY has been appointed chief engineer of Sheepbridge Engineering, Ltd., Chesterfield. He will take responsibility for all the company's metallurgical, chemical and engineering research and development work.

MR. W. GRIFFITH EDWARDS has retired from the board of Hordern, Mason and Edwards, Ltd., Tyburn, Birmingham, of which he has been a member since 1923. Mr. Edwards was formerly managing director and chairman of the company.

THE CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., has formed a company, entitled the Consolidated Pneumatic Tool Company S.p.A., to handle its business in Italy. The headquarters of this company are at Viale Piceno N.19, Milan.

COWLISHAW WALKER AND CO., Ltd., Stoke-on-Trent, has opened a London office at 17, Victoria Street, S.W.1, which is operated by a subsidiary entitled Cowlishaw Walker (London), Ltd. Mr. Norman Goodchild is the managing director of the new company.

MR. MICHAEL CLEAR, M.I.Mech.E., has been appointed group sales director of the Brush Group and a director of Associated British Oil Engines, Ltd. Mr. F. A. Vaughan has been appointed managing director of Brush Aboe (South Africa), Ltd., Johannesburg.

THE GREENGATE AND IRWELL RUBBER COMPANY, Ltd., Manchester, announces the retirement of its chairman, Mr. W. Griffin Morris, after more than fifty years in the company's service. Mr. J. Frankenburg has been appointed chairman and Mr. D. D. Marshall, deputy chairman.

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., announces the following appointments:—Mr. F. C. Hallawell, manager for Brazil, in succession to Mr. H. W. Foy, who continues in an advisory capacity; Mr. E. E. Sarasa, manager for Argentina; Mr. R. Morris, technical representative in Colombia, Peru and Venezuela.

British Patent Specifications

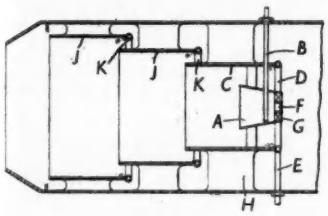
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

AERONAUTICS

691,068. April 18, 1951.—FUEL-BURNING MEANS FOR A GASEOUS-FLUID PROPULSION JET, Armstrong Siddeley Motors, Ltd., Park Side, Coventry, Warwickshire. (*Inventor: Sidney Allen.*)

The main object of the invention is to ensure satisfactory control of the combustion of "reheat" fuel, and, furthermore, that the high temperatures generated in the jet pipe (as a result of "reheating") will not damage the adjacent part of the jet pipe or airframe. It includes a flame stabilising device, a tubular casing which is short when compared with the length of the jet pipe and is spaced from the wall of the jet pipe in such a way that some of the gaseous fluid will pass between the casing and the wall of the pipe, and means for supplying fuel to an appropriate part of the casing to ensure proper combustion of the fuel. A sectional elevation of a preferred form of fuel-burning means in a jet pipe of a gas turbine engine is illustrated. *A* is the flame stabilising device and *B* a pipe by means of which a pilot supply of fuel can be delivered. The stabilising device includes a frusto-conical casing with its smaller end upstream. The casing *C* is associated with the flame stabilising device, its upstream end having an annular manifold *D*, from which fuel is sprayed into the interior of the casing, the fuel being delivered to the manifold by a supply pipe *E*. The manifold can be set at any radial position in the annular space between the casing and the stabilising device. The stabilising device has a central baffle *F* at its upstream end joined to the smaller end of the casing of the stabilising device by fixed, swirl-introducing vanes *G*. Fuel from the pipe *B* is delivered through



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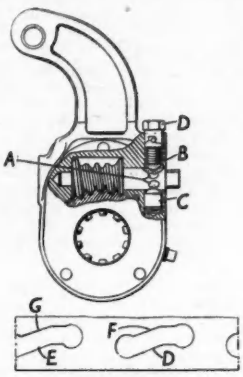
nozzle openings on opposite sides of the pipe into and against the direction of the swirl of the exhaust gases in the stabilising device. The casing *C* is supported from the jet pipe wall by means of angularly disposed streamline struts *H*. In a simple construction the single casing *C* used is of a size determined by the percentage of exhaust reheating it is desired to obtain. The size is such that the amount of gases passing through it will be sufficient to effect complete burning of the reheat fuel, the remainder of the exhaust gases passing outside the casing. These exterior gases will not have their temperatures raised to any dangerous extent, and, in consequence, the jet pipe is protected in the region of the casing where the reheating is being effected. In this case some of the reheat fuel may be directed on to the inside walls of the casing to promote its cooling, and the lower temperature of the non-reheated exhaust gases outside will also have a cooling effect on the casing. In cases in which it is desired that a greater quantity of the exhaust gases should be reheated, use can be made of more casings, as shown at *J*. Each additional casing is provided, preferably at its upstream end, with its own supply of reheat fuel, by way of the manifolds *K*.—*May* 6, 1953.

ROAD TRANSPORT

691,229. April 10, 1951.—SLACK ADJUSTERS FOR VEHICLE BRAKES, Bendix-Westinghouse Automotive Air Brake Company, 901, Cleveland Street, Elyria, Ohio, United States of America.

The invention is applied to a conventional slack adjuster comprising a casing with a worm wheel mounted on the brake cam shaft, together with a worm engaging the wheel for adjusting its position with respect to the casing in order to adjust the vehicle brakes. A positive locking detent which is employed is so designed that the worm shaft adjustment may be quickly and easily effected and the slack adjuster thereafter securely locked in position without danger of backing off. Referring to the drawing, it will be seen that a number of spaced notches *A* are arranged on the shaft. The casing has a bore for receiving a spring-loaded detent member *B*. If desired, a second spring-loaded detent *C* may be positioned diametrically opposite. One of the important features of the invention is in the use of a locking member for controlling the action of the detent *B*. This locking member *D* is capable of limited rotation in opposite directions. During such rotation the locking member may be either moved towards or away from the shaft. During movement of the locking member towards the shaft it engages the upper end of the detent member *B* effectively to lock it in the position illustrated. On the other hand, when the locking member is moved outwards the spring elongates and serves to maintain the shaft in any desired position, and the shaft may be rotated to effect adjustment of the brakes. Thereafter it is only necessary to move the locking member *D* to



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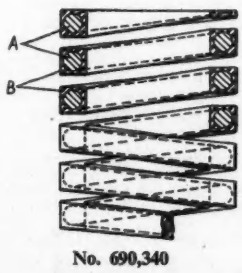
the first position in order to maintain the adjustment in a locked position. The locking member has, as shown in the lower drawing a pair of diametrically opposed similar cam slots *D* and *E*, which co-operate with a pin having its opposite ends secured to the wall of the bore. As will be seen from the drawing, the slots have inclined portions *F* and *G*, so that upon rotation of the locking member in one direction the co-operation between the inclined portions of the slots and the pin will move the member *D* axially in the bore so that the locking member is moved in one direction axially. Such movement brings the enlarged portions of the slots in such a position as to embrace the opposite ends of the pin. In this position of the parts the member *D* is moved away from the detent, the load on the spring is relieved, so that the detent becomes yieldable. When the locking member is being moved in the opposite direction towards the shaft opposite enlarged end portions of the slots will be brought into engagement with the opposite ends of the pin. The locking member will then engage the upper end of the detent and the shaft will be effectively locked in position. It will be noted from the drawing that the enlarged portions of the slots are connected to the inclined portions through slot sections which are substantially normal to the axis of the locking member. From this construction it will be readily seen that the locking action on the detent, when the parts occupy the position shown, is positive. Thus there will be no tendency toward rotation of the locking member, notwithstanding the application of heavy torques to the slack adjuster.—*May* 6, 1953.

INTERNAL COMBUSTION ENGINES

690,340. February 20, 1950.—DAMPING MEANS FOR POPPET VALVE SPRINGS, William Gilbert Hunter Nicolson, Shrubland Old Hall, Coddenham, near Ipswich, Suffolk.

According to the manner of carrying the invention into effect shown in the drawing, the coil spring *A* is completely covered with bonded synthetic rubber or other resilient material *B*, the thickness of which is



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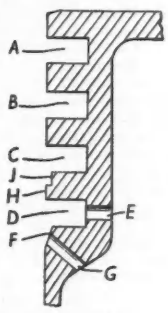
such that when the coiled spring is under maximum working compression the coating on adjacent coils is in contact. By this means sufficient contact can be provided to damp out vibrations without danger of imposing undue loading of the poppet valve operating mechanism and, at the same time, reduce surging to a minimum. The process of bonding the rubber to the spring is carried out under maximum working compression in a mould, in which the spring is incorporated in a rubber tube and the slicing of the rubber between coils is done on a mandrel after releasing the spring from the mould. Contact is thus assured between the rubber on each coil when the spring is compressed during valve operation and surging is reduced to a minimum under operating conditions.—*April* 15, 1953.

690,109. March 23, 1950.—IMPROVEMENTS TO PISTONS, John Alfred Prestwich and Edward Stuart Prestwich, Northumberland Park, Tottenham, London, N.17.

An object of the invention is to provide control of the amount of oil that can pass the piston. The drawing shows a piston for an engine of 80mm bore with four ring grooves *A*, *B*, *C* and *D* in the head portion. The groove *D*, furthest from the crown of the piston, is provided with oil holes *E* through the piston and the lower edge of the groove is chamfered with a relatively wide and shallow chamfer *F*. Additional oil holes *G* are provided. The next groove *C* is undrilled. Between these two grooves is a land *H*. Applying the invention to the piston shown, the process consists in removing part of the land between grooves *C* and *D* to the extent of half its width, namely, $\frac{1}{16}$nds of an inch, and a depth of about $\frac{1}{32}$nd of an inch, the relieved portion starting from the upper of the two grooves and forming an annular recess *J*. In a modified construction small oil holes are drilled through the piston from the lower corner of the annular recess *J*, so as to pass oil that is collected in the recess to the back of the next ring groove *D*. It is claimed that the invention provides all the advantages that are to be obtained by the use of a scraper ring with the additional advantage that the recess will not be diminished by wear of the piston ring in the adjacent groove *D*, and the reduction of the wearing surface of the piston resulting from the formation of the annular recess *J* is so small as to be of no practical significance to the life of the piston.—*April* 15, 1953.



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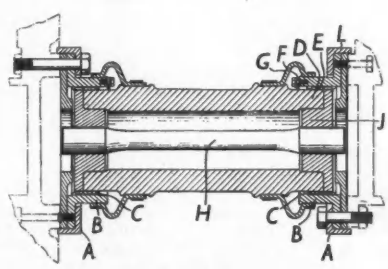
POWER TRANSMISSION

691,281. September 28, 1951.—SHAFT COUPLINGS, Transport Equipment (Thorneycroft), Ltd., of Thorneycroft House, Smith Square, London, S.W.1 (*Inventor: Alan Francis Leslie Pollitt*).

The invention is described with reference to the accompanying diagrammatic drawing which illustrates one embodiment of the shaft coupling for use with a heavy motor vehicle. Each of the driving and driven members *A*, *A* comprises a hollow cylindrical part *B*, *B*, provided with an outwardly extending fixing flange and with internal splines or teeth *C*. The internally splined or toothed cylindrical parts are of sufficient diameter to accommodate externally



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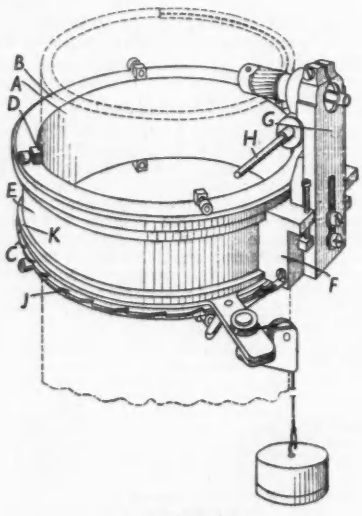
splined or toothed end parts *D* of a tubular shaft, the splines *E* on each end of the tubular shaft occupying only part of the length of the splines on the respective driving or driven member. A stop *F* is fixed to the inner end of the cylindrical part of each internally splined member to prevent possibility of disengagement of the splines on the shaft. Flexible annular sealing members *G* may be provided between the shaft and the driving and driven members. A co-axial torsion bar *H* within the shaft has splined on it at each end an end member *J*. This end member has a boss fitting closely but rotatably within the end of the tubular shaft. An outwardly directed flange on *J* is provided at its periphery with splines to

engage the internal splines or teeth *C* of the respective driving or driven member in a similar manner to the splines at the adjacent end of the tubular shaft. One end member on the torsion bar is engaged with the splines of the respective driving or driven member, and the other end member is forcibly turned to apply a suitable preloading to the torsion bar before its splines are engaged with those of the opposite member. The amount of preloading should exceed the maximum instantaneous torque of the engine and preferably is applied in a direction opposite to the engine torque. When the torsion bar is preloaded in this manner the end members *J* are pressed inwards so as to abut the ends of the tubular shaft and may be fixed on the torsion bar. In order to prevent any possibility of disengagement of the end members from the internally splined driving and driven members, each has an end plate *K* fixed to serve as a stop to limit outward movement of the end member *J*. An externally flanged ring *L* may enclose the outwardly extending flange of the driving or driven members and the end plates of the assembly, and may be fixed to the engine or flywheel and clutch assembly by means of bolts.—*May* 6, 1953.

MACHINE TOOLS

691,064. May 17, 1951.—HAND OR MACHINE TOOLS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2 ; and Henry James Foxon, of Research Laboratories, The General Electric Company, Ltd., Wembley, Middlesex.

One form of construction of a tool in accordance with the invention is shown in the accompanying drawing with the tool assembled for use on a rectifier, the latter being shown in chain dotted lines. The tool comprises a guide ring *A*, the internal diameter of which is slightly greater than the diameter of the part of the rectifier on which it is to be mounted. The guide ring has upper and lower flanges *B* and *C*, each of which carries four clamping bolts *D*, which engage a part of the rectifier. The guide ring has on its exterior a channel formed between the flanges, which provide radial and axial guidance for a carriage *E* which slides around the guide ring. To permit assembly of the carriage the guide ring may be formed in two parts, the upper flange *B*, for example, being separable from the main part of the guide ring and the lower flange *C*. The carriage *F* is provided with vertical guides for an arm *G*, the upper end of which is apertured to receive a boss of a supporting head for a cutting tool. The supporting head includes a worm



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drive mechanism to enable the tool to be rotated at a suitable speed by turning a shaft *H*. The vertical position of the cutter can be adjusted to control the depth of cut by sliding the arm in the guides under the control of adjusting screws. The axis of rotation of the cutting tool can be inclined to provide an oblique cut. Around the outside of the lower flange is a series of ratchet-like serrations *J*, which can be engaged by a pawl mounted from an annulus *K*, which, like the carriage, rotates about the guide ring. The pawl can be arranged to secure the annulus to the guide ring at any one of a number of positions around the guide ring. After the annulus has been secured in an appropriate position in relation to the guide ring tension is applied through a flexible cable, which has a weight attached to its other end. The arrangement is such that the tension in the flexible cable moves the carriage around the guide ring as cutting proceeds. In order to cut around the whole periphery it is necessary to attach the annulus in several different positions around the flange.—*May* 6, 1953.

Technical Reports

Simplified Calculations for Rate of Rise of Restriking Voltage (Ref. G/T261). By J. A. Callow, B.E., B.Com., A.M.I.E. (Aust.). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—This report describes a simple approximate method of evaluating rates of rise of voltage directly from the circuit constants of supply networks. The method can be used to obtain either the simple rate of rise for single frequency circuits, separate rates of rise for the higher and lower frequency components of double frequency circuits, or for the latter, an equivalent rate of rise according to the convention suggested by J. S. Cliff. The method given should provide a satisfactory means of rapidly surveying the range of rates of rise of voltage to which switchgear at a given site or number of sites is subject. Whilst the calculations are only approximate, and in the more complicated cases cannot be supported by theoretical reasoning, the method will clearly indicate which of a given number of conditions are those which set limits. The latter may then be examined more closely by complete analysis, in which appropriate account can be taken of details of network parameters which are neglected in the wider survey. Such a complete analysis is in any case necessary to show precisely the form of the transient, a piece of information which, in the present state of the art, it is probably necessary to study when limits are being considered.

The Performance of 440V A.C. Fuses with Small Over-Currents (Ref. G/T266). By H. W. Baxter, B.Sc. (Eng.), A.M.I.E.E., and M. T. Cree. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s., postage 3d.—It appears from past tests that some fuses may have difficulty in breaking small over-currents. The test facilities then available only permitted a.c. fuses of up to about 30A rating to be tested and the results were largely negative, in that no failures occurred. It was thought that the tendency for a fuse to fail with small over-currents might be more pronounced with fuses of larger current ratings, and the recent installation of new equipment and the provision of additional power supplies (sustained currents up to 700A at 440V) have enabled the performance of fuses of up to 400A rating to be investigated. Fuses of smaller rating than 200A were not tested, because there appeared to be no need for investigation below this current. The investigation was confined to commercial fuses since this enabled several different forms of construction, difficult to reproduce in the laboratory, to be investigated. All were 440V B.S. 88 : 1947 category A.C.4 fuses.

Intrinsically Safe Electrical Apparatus : Relation of Igniting Current to Circuit Inductance for Inflammable Mixtures of Benzene and of Cyclohexane with Air (Ref. G/T268). By E. M. Guenault, M.Sc., Ph.D., and E. Atherton. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 6s., postage 3d.—The report covers the determination of the range of mixtures with air of the vapours of benzene and of cyclohexane which are the most easily ignited by the sparking produced by rapid interruption of an inductive circuit, and of the relation, for such mixtures, of igniting current to the circuit inductance. It is found that these mixtures are very similar in their ignitability to the most readily ignitable mixtures of pentane and air.

Report on Researches with Ferroelectric Materials (Ref. L/T257). By H. F. Kay. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—This report deals with recent work on ferroelectric materials in the Physics Department of Bristol University. The chief aim of this programme has been the production of crystals suitable for X-ray and optical crystallographic studies, which means that only very small crystals have been produced. Crystals suitable for electrical investigations are of necessity much larger and such production has not been attempted in this laboratory. It might be added, however, that some effort might be usefully expended in this direction, but emphasis must be laid on the fact that special furnaces will be required and the services of an inorganic chemist might be essential.

Tests on Italian Design of a 275kV Single-Circuit Suspension Tower (Ref. O/T9). By P. J. Ryle, B.Sc. (Eng.). The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—The report describes tests on an Italian design of a 275kV single-circuit suspension tower and gives descriptive comparisons between British and Italian (Societa Anonima Elettrificazione) tower designs.

Review of the Technical and Economic Position of Selenium (Ref. Z/T90). By A. M. Cassie, M.A., B.Sc., M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s., postage 3d.—The increase in the use of selenium in industry in recent years has been very rapid. Demand has already outstripped supply by a considerable margin. The economic and technical consequences of this situation, particularly in relation to the electrical industry, are discussed in terms of (*a*) increasing supply, (*b*) search for alternative materials and devices, (*c*) economy in use and recovery, both in production and after service, (*d*) allocation of existing supplies amongst the various claimants. It is concluded that the latter is a matter of importance and urgency in overcoming in part the short term needs of the situation. Long term requirements can be met only by intensive research and development of alternative materials and devices in all the user industries concerned.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24 Victoria Street, London, S.W.1.

PLAIN LIMIT GAUGES : LIMITS AND TOLERANCES

No. 969 : 1953. Price 3s. 6d. This revised standard is based on the principle of having a general "go" gauge, with its tolerance zone inside the work limits, in place of the former "workshop" and "inspection" gauges.

In it tolerances in inch and metric units are specified for plug, ring and gap gauges, and guidance in the application of the tolerances is afforded by the inclusion of tables showing the minimum gauge tolerance appropriate to various types and sizes of gauges. Explanatory text is included and examples of the use of the tables are given in an appendix.

LETTER SYMBOLS AND ABBREVIATIONS IN PHYSICS, CHEMISTRY AND ENGINEERING

Draft for comment. The British Standards Institution has circulated, for comment, a draft British Standard "Letter Symbols, Abbreviations and Signs of Common Interest in Physics, Chemistry and Engineering." This draft constitutes a proposed revision of B.S. 560 : 1934, "Engineering Symbols and Abbreviations," and B.S. 813 : 1938, "Chemical Symbols and Abbreviations." Comments or views on this draft are invited at the address given above, by June 11th, 1953.

CORRUGATED FURNACES FOR CYLINDRICAL BOILERS

No. 1971 : 1953. This is a new British Standard and supersedes B.S. 3023, "Corrugated Furnaces and Smoke Tubes for Marine Boilers," which was published in 1926. It specifies requirements for corrugated furnaces for both land and marine cylindrical boilers and covers the Fox, Morison, Deighton, and suspension bulb types of furnaces with various throat designs and typical connections for riveting or welding. Dimensions of corrugations and lengths of furnace are given, together with formulæ for determining the minimum thickness of the furnaces. Requirements for materials, construction and heat-treatment are also given. The shapes of furnaces and end connections are illustrated.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INCORPORATED PLANT ENGINEERS

Thurs., May 28th.—S. YORKSHIRE BRANCH : Grand Hotel, Sheffield, "New Developments in the Coal Mining Industry," 7.30 p.m.

Fri., May 29th.—BIRMINGHAM BRANCH : Imperial Hotel, Temple Street, Birmingham, "Dust Control," R. J. Pitt, 7.30 p.m.

INSTITUTION OF GAS ENGINEERS

To-day, May 22nd.—NINETEENTH ANNUAL GENERAL MEETING : Business Sessions will be held at Church House, Westminster, London, S.W.1.

INSTITUTION OF MINING AND METALLURGY

Thurs., May 28th.—Geological Society, Burlington House, London, W.1, Annual General Meeting, Part I, Corporate and Non-Corporate Members only, 4 p.m.; Part II, incorporating Presidential Address, J. A. S. Ritson, 5.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, May 22nd.—YORKSHIRE GRADUATE SECTION : Works Visit to Wm. Asquith, Ltd., High Road, Halifax, 6.45 p.m.

Wed., May 27th.—SHREWSBURY SECTION : Technical College, Shrewsbury, "Electronics as an Aid to Productivity," R. McKennell, 7.30 p.m.

NEWCOMEN SOCIETY

Wed. to Fri., May 27th to 29th.—University Arms Hotel, Cambridge, Summer Meeting.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., May 26th.—Manson House, Portland Place, London, W.1, Annual General Meeting, 6 p.m.; "The Instrumentation of Pilot and Experimental Scale Plant," W. A. Goldstein, 7 p.m